WATER POWER

A technical journal devoted to the study of all aspects of Hydro-electric developments

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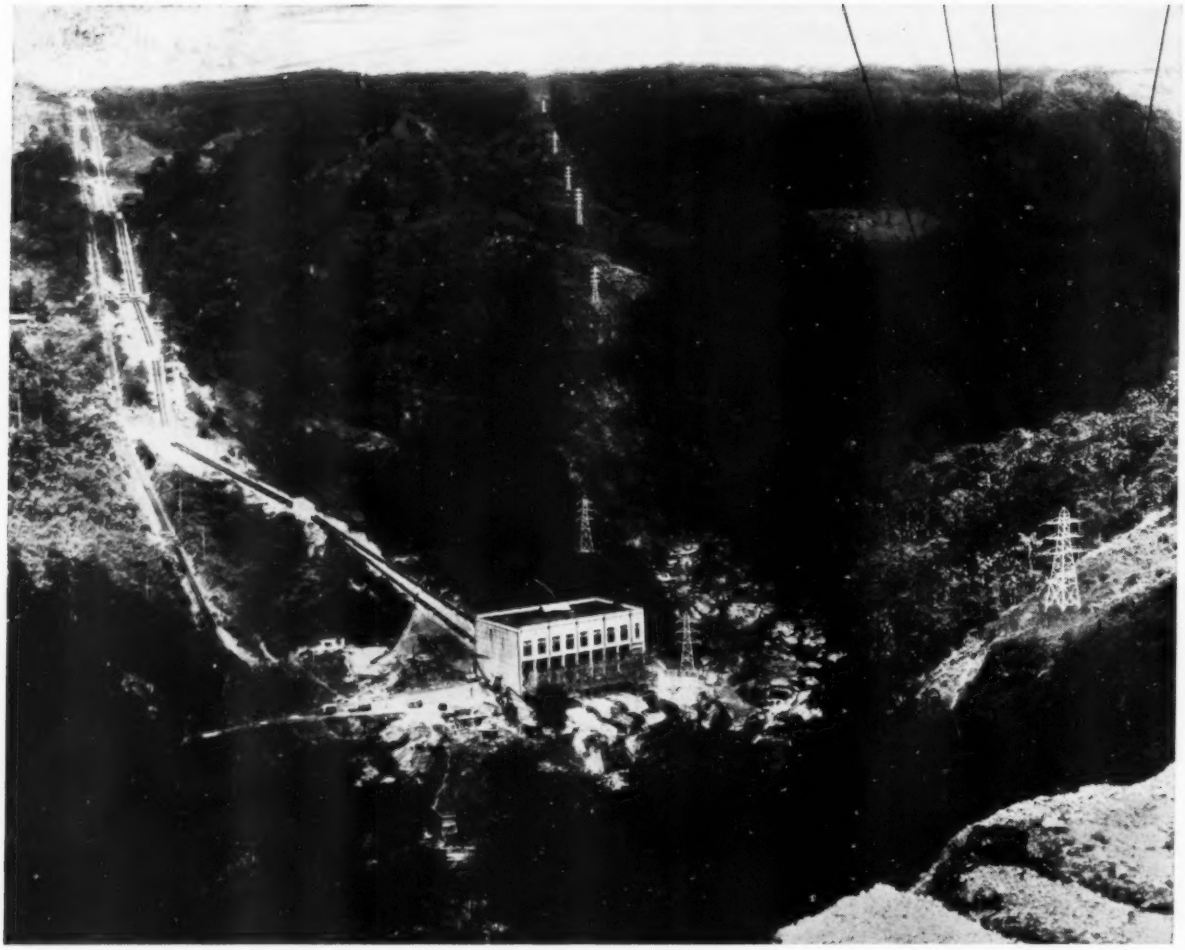

Across 78 MILES of country like this ...

BICC OVERHEAD TRANSMISSION

It's a tough job erecting lines and towers across the mountains, valleys and jungles of Ceylon. But BICC Engineers are used to work of this nature : they have recently completed the overhead transmission system for the first stage of the Laksapana Hydro-Electric Scheme. This comprises seventy-eight miles of double-circuit 66kV line to carry 25,000 kW of power to Colombo and Peradeniya.

Survey, siting, supply and erection of this transmission system were all carried out by the BICC group—who undertake similar installations anywhere in the World.

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WATER POWER

A technical journal devoted to the study of all aspects of Hydro-Electric Development

Financing Hydro-Electric Schemes

DURING the last 60 years—the period in which large-scale hydro-electric development has taken place—there has been a change in the sources from which the necessary finance has been drawn. In the early days, by far the largest amount of capital for power development came from private sources, and great honour is due to the early pioneers, not only those who tramped painfully through virgin forests to survey unexplored catchment areas, but also to those, sitting safely in city offices, who nevertheless had the vision to risk substantial sums of their own money on what seemed the nebulous future of electrical power demand. The fact that the engineers of those early days knew their business is proved by the many installations which are still efficiently delivering power 30, 40 and even 50 years after they were first commissioned.

But with the increase in the demand for electrical energy, particularly in those territories where a high level of industrialisation was reached, the scale of operations became such that governments felt it incumbent on them to take a hand in power development. Moreover, during the last two or three decades, the economy of many countries has become so linked to their sources of power that their very existence depends on hydro-electric development and this inevitably brings an ever-increasing degree of state control, and its concomitant, state finance.

This trend, of course, is not universal. In the United States, for example, a fierce fight is being waged against any encroachment by the state on the rights of private companies to develop hydro-electric resources, even though the necessity for the Tennessee Valley Authority is now accepted. (It may be mentioned here, however, that the Authority's main function was that of water control and irrigation, rather than that of power development alone.)

The changing political scene in the postwar years has revealed very clearly that power development is more and more considered to be a national affair, and not one for private enterprise. It is only natural that such huge developments as the Snowy River scheme should be beyond the reach of private finance; and when, for example, in Sweden it became necessary to reach out for the unprecedented distance of nearly 700 miles, into the far Arctic North, to bring in new power supplies, the capital risk involved was too great for any organisation less well endowed than the State Power Board. This investment can only reap its reward after many years.

In Great Britain, in France, in many parts of India, naturally in the huge territories of the U.S.S.R., in New Zealand, and in parts of Canada, to take only a few examples, the future of all power development is in state hands.

It is of interest to speculate on the effects of this increasing degree of state enterprise, as opposed to private enterprise, in the hydro-electric field. State management brings with it, inevitably, "red tape," slowness in reaching decisions, a multitude of committees, and the possibility that political cross-currents will erode the waterwheels. As an example of this, the Snowy River development is under political fire at the present time. Even though the principal argument for a revision of the scheme is apparently the technical one that nuclear power may provide more economically for Australia's future energy needs, the fact that various state legislatures have power to modify the scheme, as well as the Federal Government, may at the least lead to delay. But, on the other hand, the price of current from the Snowy River development will be cheaper than it would have been if private financial interests had had to embark on such a vast and long-term project.

Money can be made available from the coffers of a government for schemes that are so long-term that no other form of finance could prudently have been applied to their development.

On the other hand, there is less likelihood of technical pioneering by state-controlled bodies. They must always play for safety, and electricity-supply officials of all kinds are usually the most conservative of all engineers. As an example of this there may be cited the number of reports and enquiries into the possibility of using pumped storage in Great Britain, which have been found necessary before an actual

project can be set in motion, although such schemes have long become an accepted part of hydro-electric practice in other countries.

There are still vast undeveloped areas of the world; for example, in the temperate and as yet undeveloped regions of Africa and South America, where the private enterprise power company has still an important part to play in harnessing the enormous amounts of power awaiting exploitation. Untapped mineral resources, which can only be economically refined by electrical means, will provide the vehicle for adequately rewarding those who venture their capital in water-power projects of the future.

However much the gradual passing of the private power company, with its pioneering outlook, and often with its brilliant engineers who made daring compromises with nature, may be regretted, there is one consoling thought. No change in world power-production methods, such as the technical, and possibly economic, incidence of power supplies from nuclear plants is likely to affect the security of hydro-electric investment. It is still the world's most elegant and most efficient method of power production.

Rance Tidal Scheme Approved

WORK is expected to commence shortly on the tidal scheme devised by Electricité de France to exploit the estuary of the Rance in Brittany. A barrage, enclosing an area of nearly 40 sq. km., is to be built north of the Rance estuary upstream of St. Malo, St. Servan and Dinard on a line connecting the Briantis head on the right bank with the Brebis head on the left bank, and the scheme has now been approved by the municipalities involved. The power station will be equipped with 26 8·5 MW Kaplan generating sets and will operate on a single ebb cycle. The annual output is estimated to be about 550 million kWh.

Invergarry Tunnel Holed Through

WORK was recently completed on the driving of the low-pressure tunnel on the £3,000,000 Invergarry hydro-electric project for the North of Scotland Hydro-Electric Board. The tunnel conveys water from Loch Garry in Inverness-shire to an underground generating station at Invergarry, whence it is discharged through the tailrace tunnel, under the main trunk road from Inverness to Fort William, into the lower reaches of the River Garry.

The tunnel is 2¾ miles long and, when lined with concrete, will be equivalent to 16 ft. 6 in. in diameter. Tunnel driving has proceeded from a shaft 75 ft. deep at the intake end of the tunnel and an adit at the outfall end for a period of 21 months. During this time, the average weekly progress, working on 12 hour shifts, has been 88 ft. per heading, while the peak progress in the adit drive was 155 ft. per week. As the excavated size of the tunnel is 10 cu. yards per foot run, this represents the removal of over 3,000 tons of rock in one week, using two Eimco 21 rocker shovels. The drilling equipment used was the Atlas Diesel 656W in one heading and the Consolidated Pneumatic CP59 in the other, mounted on air legs and using tungsten-carbide-tipped drill steels. The dipping heading has required a considerable amount of pumping, due to water running through fissures in the rock, and it is estimated that, while tunnelling has been in progress, over 100 million gallons of water have been pumped out. A pilot hole, which indicated an extremely accurate junction, was drilled when 13 ft. of rock remained between the headings and the ceremony of pressing the button firing this last round was performed by Mrs. James Robertson, wife of the managing director of Whatlings Limited.

The station, when complete, will have a capacity of 20,000 kW, and the civil-engineering works are programmed for completion at the end of 1954. The consulting engineers for the project are Sir William Halcrow & Partners, and the civil-engineering contractors are Whatlings Limited, 10 Woodside Crescent, Glasgow, C.3.

McNary Generator Contract

THE contract for the manufacture and installation of two waterwheel generators, physically ranking among the largest ever built, has been awarded to The English Electric Export & Trading Company Limited by the United States Army Corps of Engineers at a cost of $3,651,476, which was the lowest bid received (approximately £1,300,000). The maximum output of each generator will be 84,740 kVA at 13·8 kV, 60 cycles, 85·7 r.p.m. (approximately 108,000 h.p.).

The hydro-electric station at the foot of McNary dam, built across the Columbia River in the north-west of the United States of America, is designed to accommodate 14 generating sets, having a total maximum output of 1,186,400 kVA. The two machines under the present contract will complete this station and are due for commissioning before December 1956.

Well over 1,000 tons of material, mainly special steels and copper, are required for the construction of each of these units, which will have an overall dimension of nearly 52 ft. To facilitate transport and erection, each stator will be split into several parts. The complete stator will weigh about 180 tons and will have an outside diameter of approximately 42 ft. The assembled rotor will be about 35 ft. in diameter and 5 ft. deep. With the shaft—which will be nearly 35 ft. long and will weigh some 80 tons—and other fitted parts, the rotor weight will approach 500 tons.

Japanese Tender for Snowy Mountains

A JAPANESE firm, it is announced, has submitted the lowest tender for an important section of the Snowy Mountains hydro-electric scheme. The tender refers to a large block of works which include a 15-mile tunnel, a dam at Tumut Pond associated with a further tunnel three miles long, and an underground power house. Some diffidence is expressed in official quarters at accepting a Japanese tender, but it is recognised that it would help to adjust the trade balance between Japan and Australia, which in recent years has been heavily adverse to Japan.

If the works proceed to schedule it is expected that the first unit of the power house, developing 125,000 h.p., will be ready for operation in 1958.

Burdekin Falls Scheme

ACCORDING to the Third Annual Report of the Burdekin River Authority tentative designs for a mass-concrete spillway type of dam have been prepared and a tentative layout has been decided upon for an underground power station. A programme of

diamond drilling, together with the sinking of deep test shafts at selected points, has failed to reveal any defects in the foundations, and a suitable material has been found for the necessary aggregate in the shape of a granitic rock which outcrops near the main access road, within a short distance of the site of the dam. Preliminary investigations of the construction procedure suggest that revolving cranes, mounted on a gantry, are likely to achieve the most economic placing of the concrete and formwork.

Restriction of funds has precluded the raising of a loan to enable a full-scale construction programme to be followed, but work is proceeding on a stage-development basis with day labour, without any large contractual commitment having been made.

Stornorrfors Plant, Sweden

PLANS for the Stornorrfors plant are now sufficiently advanced for the order for three vertical spiral-cased turbines to have been placed. This plant, which will be sited on the Ume river, will be the largest hydro-electric plant in Sweden—exceeding even the Harsprånget installation in magnitude. The net head available is 73 m. and each unit will be capable of discharging 200 cu. m. per sec., developing 78,000 h.p. at 125 r.p.m. Each runner, which will have a diameter of 5·15 m., will weigh approximately 55 tons. The order for the cased turbines has been placed with Nydqvist & Holm Aktiebolag (NOHAB) of Trollhätten.

Portuguese Hydro-Electric Expansion

THE electrical statistics for 1952, which have just been published by the Portuguese Ministry of Economics, show that the phenomenal expansion in hydro-electric development in that country previously revealed by the 1951 statistics continues steadily. Installed hydro-electric capacity increased from 362 MW in 1951 to 460 MW in 1952, due mainly to the commissioning of further sets in the country's major stations. Thus the capacity of Castelo do Bode was increased from 91,840 kW to 137,760 kW, of Vila Nova from 51,200 kW to 76,800 kW, and of Belver from 8,000 kW to 32,000 kW.

Even more significant is the continued swing-over from thermal to hydro-electric generation. The output from hydro-electric stations increased from 813 to 1,194 million kWh, whereas that from thermal stations, in spite of a moderate increase in installed capacity from 193 to 198 MW, fell from 231 to 145 million kWh. Total generation increased from 1,043 to 1,339 million kWh.

Now that the Salamonde station has been inaugurated we may expect the figures for 1953, when available, to be equally interesting.

Lillooet Plant

FURTHER to our note last month we are now able to give additional details of this project which is being constructed by The British Columbia Electric Co. Ltd. The contract has been awarded to the Emil Anderson Construction Co. Ltd., of Hope, which submitted a bid of just over $4 million for the job. This includes the construction of two low-level dams, a 12,000 ft. concrete-lined canal, and the erection of the power station to house the 58,500 h.p. generating unit. Contracts for the turbine, generator, step-up transformer and control equipment have been let to Canadian Allis-Chalmers Limited and to Canadian Westinghouse, the former firm being responsible for the turbine and the latter for the rest of the equipment. It is expected that the plant will be completed by the midsummer of 1956.

The Seton plant will be arranged for automatic operation and no personnel will actually be employed at the station; electrical impulses from the Bridge River station, 18 miles west, will initiate the starting and stopping of the set and all the other routine functions. Power from the new station will be fed into the existing 60,000 V line now serving Lillooet and the surrounding area; excess energy will be transmitted to Bridge River and thence along the Bridge River transmission line to Vancouver.

Two diversion dams, one on Seton Creek and another on Cayoosh Creek, will channel the flow into the power canal which, in turn, will deliver the water into a penstock having a drop of 140 ft. to the reaction-type turbine. A fish ladder will be provided to allow spawning salmon to continue their upward trip into Seton Lake, as they do at the present time. On Cayoosh Creek dam, perhaps because of its extreme seasonal variation, which ranges from a raging torrent to a mere trickle, no fish ladder will be required as salmon have never been attracted to this stream.

In a recent announcement, Mr. Tom Ingledow, vice-president and chief engineer to the B.C. Electric Company, stated that the basic idea in the Seton development was to use water from the Bridge River a second time, rather than let it flow uselessly away. About 80 per cent. of the new plant's water supply, he continued, would come from the water poured into Seton Lake from the Bridge River station and the rest would be derived from the natural run-off from Seton Lake and the nearby Cayoosh Creek, which joins the outlet of the lake some way down to the Fraser valley.

St. Lawrence River Scheme

MR. R. A. BUTLER has stated that he is anxious to facilitate British participation in the St. Lawrence Seaway and Vancouver Isles schemes, and that he would "try his best" to provide dollars for any suitable project. It will be recalled that this project has the dual objects of opening up the Great Lakes to ocean traffic by means of a seaway canal and providing a large block of hydro-electric power.

L. F. Harza

IT is with great regret that we record the death at the age of 71 of L. F. Harza, head of the well-known firm of consulting engineers which bears his name. Mr. Harza's reputation as an expert on hydro-power projects stretched far beyond the confines of the United States, great as they are, and indeed it is only recently that he called at these offices on his way to India, which he was visiting in connection with the Damodar Valley scheme.

He was a good friend to this journal and we are not only indebted to him for his encouragement and advice but also for the enriching experience he afforded us of meeting a personality that was at once so full of humanity and humour, and so knowledgeable and wise.

Fig. 1. Molina dam from upstream

Calancasca Development

Although of moderate size, this scheme presents many features of interest. Separate summer and winter intakes are provided, so that the reservoir can be emptied during the summer and silting removed. The underground station contains two 10 MW Pelton-driven sets and is remote controlled.

THE valley of the Calancasca, a tributary of the Moesa, is one of those parts of Switzerland whose romantic character is inversely proportional to the resources available for its inhabitants. The exploitation of this site thus makes an inmportant contribution in encouraging farmers to remain in this difficult mountain region.

Although the Calancasca is one of the smaller sources of water power in the country, local conditions are so favourable that the site was first investigated more than 35 years ago. Only a short tunnel, about 10,000 ft. (3 km.) long, is required to exploit a catchment of 52 sq. miles (134 sq. km.) which extends up to the Zapporthorn without including any glaciers, and which provides a head of some 1,200 ft. (360 m.).

It was, however, the scarcity of electric power during and after the last war which provided the final impetus to tackle this difficult project. While avoiding excessive capital costs and heavy loss in agricultural land, it was found possible to arrange in the lower Calancasca valley a weekly storage reservoir which during winter provides on five weekdays more than 100,000 kWh spread over a few hours. This represents an appreciable contribution towards meeting the regular peak demand.

The Calancasca station was completed in the autumn of 1951; the firm of Elektro-Watt, Zürich, was responsible for the general design and for supervision during construction. It utilises a maximum total head of 1,352 ft. (405·6 m.) between Buseno and Sassello on the Moesa (Fig. 2). Based on observations extending over many years, a flow of 220 cusecs (6 cu. m. per sec.) is expected on the average on 134 days annually. With an installed capacity of two 10,100 kW sets, the average annual energy production is approximately 100 million kWh of which 30 per cent. are obtained in winter (October to March).

The Water Intakes

In order to prevent silting up of the reservoir, run-of-river operation is employed during the summer when the storage reservoir is emptied completely. A summer intake (Figs. 3 and 4) is provided for this

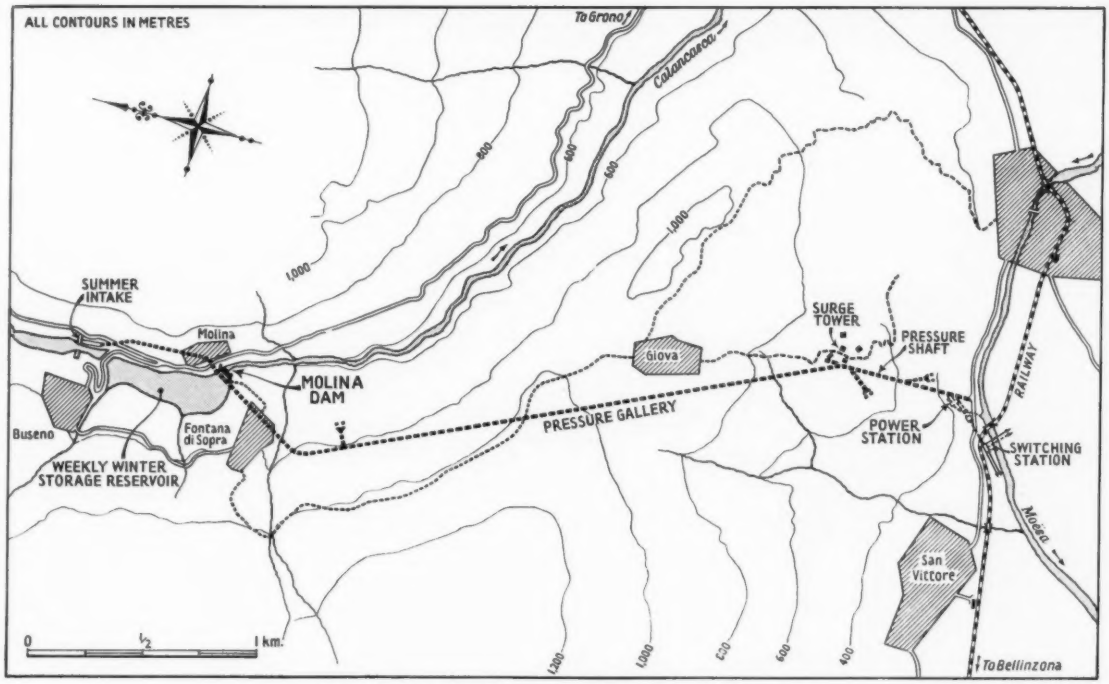


Fig. 2. Layout plan of the Calancasca scheme

purpose from which the water is led to the main gallery by a short tunnel. The required head is obtained by a movable weir built into the river bed. Its main opening contains a double sector gate of novel design, 50 ft. wide and 13 ft. high (15 m. × 3·8 m.), while a similar gate closes the scour opening 5 ft. wide and 10 ft. high (1·5 m. × 3 m.). A winch house above the scour gate contains all the lifting gear.

The upper sector is controlled automatically so as to provide a constant water level at all river discharges. The right-hand abutment contains the float chambers for the automatic gate control and for the water-level transmitter, while the actual control gear is located in the winch house above.

Although the flow of the Calancasa is comparatively small, only about 1,100 cusecs (30 cu. m. per sec.) when the snow is melting, storm floods of up to 7,500 cusecs (200 cu. m. per sec.) have been recorded. The structure is designed to pass safely double this quantity without danger of damage.

During periods of high flow the river contains large quantities of very hard sand. In order to reduce the wear on turbine nozzles and buckets, an automatic desanding plant has been arranged behind the intake (Fig. 4) capable of separating out all sand particles exceeding 0·014 in. (0·35 mm.) diameter. It consists of a fully enclosed chamber 170 ft. (50 m.) long: its intake gate is motor driven and can be controlled remotely from the power station. A tunnel 2,000 ft. (600 m.) long and 6 ft. (1·8 m.) diameter leads to the Molina dam; its general slope is 1 in 220, with a short steep drop of 1 in 1·4 to make up for the level difference to the pressure gallery.

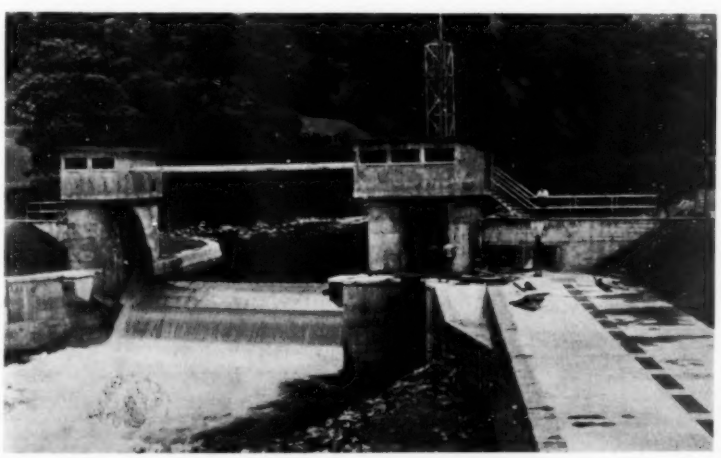


Fig. 3. Buseno summer intake with enclosed desander on the right

At low rates of river flow, only the reservoir at Molina is in operation, providing a useful storage capacity of 24 million cu. ft. (760,000 cu. m. per sec.) corresponding to 67 ft. (20 m.) change in level. Although the surface conditions seemed ideally suitable for a light arch dam, a gravity structure 50 ft. wide and 150 ft. high (15 m. × 45 m.) was eventually decided on because of the geology of the site (see Figs. 5 to 7).

A bottom outlet at river-bed level, 20 ft. wide and 13 ft. high (6 m. × 4 m.), can readily pass the maximum expected flood discharge. Its sector gate is

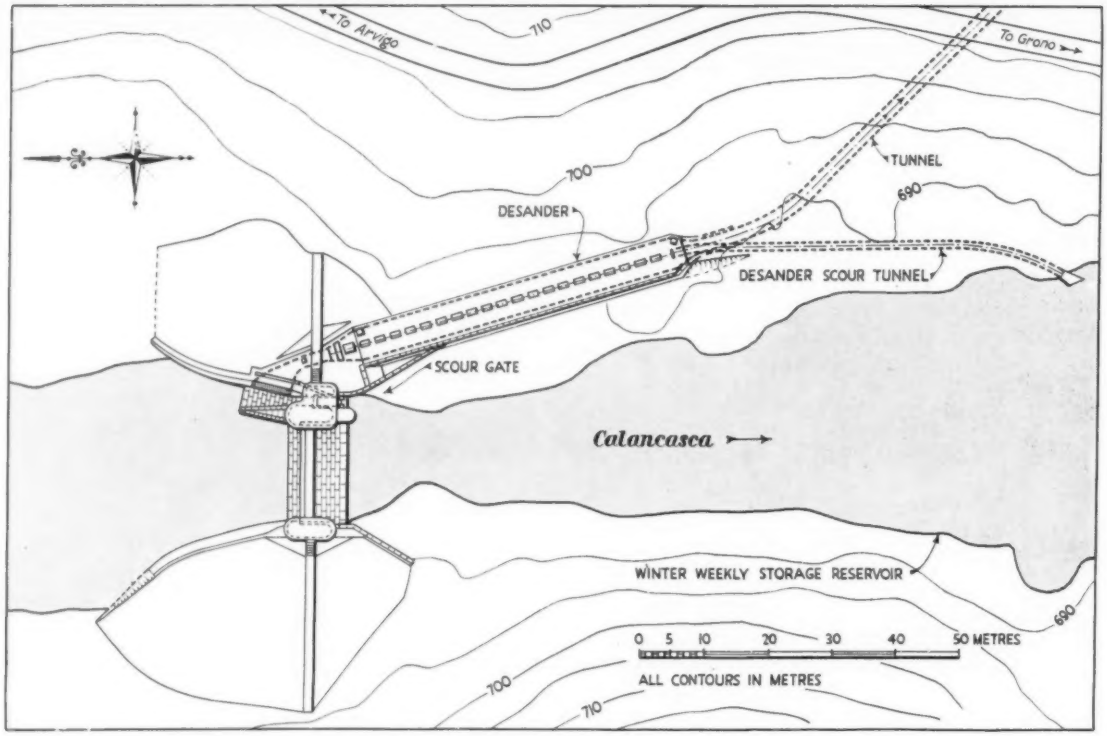


Fig. 4. Layout of Buseno summer intake

supported at four points and special care has been taken to reduce leakage, the maximum loss of water being less than 200 g.p.m (15 l/sec.) The winding gear is driven by a 2 h.p. motor located above the gate and operates through two racks. As an additional safeguard, two spillways are provided which are capable of passing more than 15,000 cusecs (400 cu. m. per sec.) at a head of 10 ft. (3 m.) above the sill. One spillway runs over the dam itself while the other discharges over a low side embankment and rejoins the river further downstream.

The dam intake is protected by a circular screen and contains an automatic safety valve which can also be operated remotely from the power station. It then discharges into the 5 ft. (1·4 m.) diameter steel pipe which takes the flow from the summer intake through the dam structure.

A pressure gallery 9,500 ft. (2·85 km.) long and 6 ft. 8 in. (2·0 m.) diameter, with a slope of 1 in 220, runs from here to the surge chamber at the hamlet of Monti. The maximum head in the tunnel rises from 87 ft. (26 m.) at the dam to 167 ft. (50 m.) at the surge tower. The latter consists of two horizontal chambers arranged above each other and joined to the tunnel by a vertical shaft. The steel-lined penstock shaft is 2,000 ft. (600 m.) long and 5 ft. (1·5 m.) diameter; it follows a slope of 1 in 1·25 down to the short final horizontal section and the turbine manifold. The thickness of the lining increases from 0·32 in. (8 mm.) to 0·5 in. (13 mm.) at the bottom of the slope, with a further increase up to 0·8 in. (20 mm.) as the power station is approached. The manifold varies in thickness between 1·2 and 0·64 in. (30 and 16 mm.), depending on the pipe diameter. The whole lining up to the rotary valves is constructed from boiler plate and weighs 260 tons.

The Hydraulic Turbines

The equipment of the Sassello station is laid out in two parallel tunnels (Fig. 8). The main hall is 130 ft. long and 30 ft. wide (40 m. × 9 m.), with access from the main road by a 250 ft. (75 m.) tunnel. The smaller chamber contains the rotary turbine valves operated by pressure water from the penstock; they close automatically if a pipe should fail, and can be operated by remote control.

The two horizontal-shaft Pelton turbines (Fig. 9) were supplied by the Ateliers de Constructions Mécaniques de Vevey and are fitted with two jets and deflectors. Their output is 14,000 h.p. under a net head of 1,330 ft. (400 m.) at a flow of 110 cusecs 3 cu. m. per sec.); they operate at 500 r.p.m. and have a runaway speed of 900 r.p.m. The machines are of conventional design, with cast-iron casings containing reinforcements and deflecting faces of cast steel; they are anchored securely to the foundations to prevent vibrations. The long bifurcation between manifold and turbine was partly welded up on site; this was followed by a pressure test at 850 lb. per sq. in. (60 atm.), 1½ times the static head, which also included the two turbine nozzles and the turbine valve connecting pipes.

The turbine runners are 5 ft. 4 in. (1,600 mm.) in diameter and were cast in one piece. Special methods were employed to finish the buckets accurately to the required shape. The braking jet provided on each

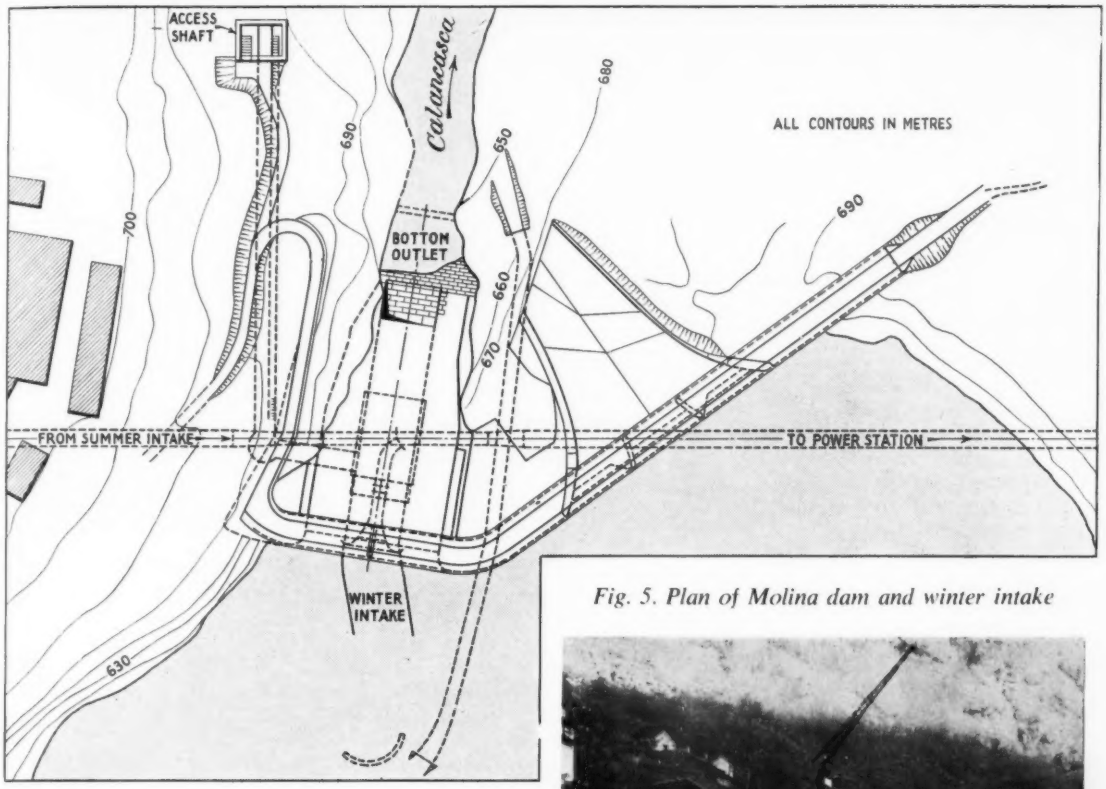


Fig. 5. Plan of Molina dam and winter intake

turbine is arranged to impinge on the bucket reinforcements instead of on the weaker central part.

Each set runs on three bearings; all axial loads are taken up by the centre bearing which is carried on the alternator. The turbine bearing is designed for a 15 ton load and is fitted with an independent oil circulating system; it can be dismantled completely without having to disconnect the shaft.

The governors work on the standard Vevey system which responds to both the acceleration and the speed of the set (Fig. 10). They are placed adjacent to the turbine and incorporate the following facilities:—

(1) manual and electrical speed adjustment;
(2) manual and electrical stroke limitation;
(3) adjustment of governor sensitivity while running;
(4) rapid shut-down of turbine by the protective devices;
(5) indicators and instruments for supervising governor operation;
(6) varying the ratio of acceleration to speed sensitivity while running, to match the electrical system.

Oil pressure is provided by two screw pumps; one is driven from the d.c. supply and used for starting up, while the other is connected to the turbine shaft and comes into operation when the correct speed is reached.

Conditions at Sassello make it desirable to operate the turbines with either one or two jets, depending on the flow available, thus appreciably increasing the efficiency at low discharges. The jets can be switched on and off during running, either manually or

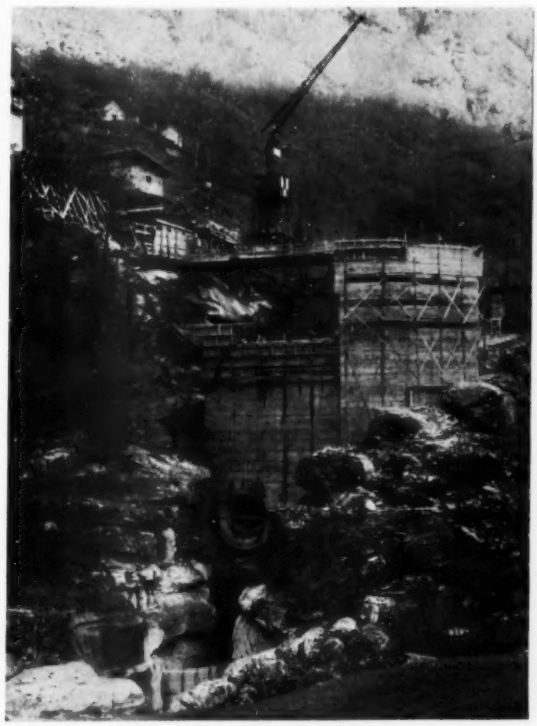


Fig. 6. Molina dam under construction showing the winter intake

electrically, since separate hand and electrical controls are provided for each nozzle.

The following safety features are included in the scheme:—

(a) an overspeed device controlling a water servomotor which operates the jet deflectors and closes the

turbine valves electrically through a contact;

(b) a number of excess oil-temperature indicators which act directly on the governor;

(c) an interlock which prevents accidental starting of the oil pumps and opening of the valves and nozzles while the turbine is under repair.

The sets can be started automatically, using only a single pushbutton, after the first nozzle to open has been selected. The electrically driven oil pump starts up first, followed by the turbine valve which opens when the correct oil pressure has been reached. An electrical contact then allows the jet needle to open. Once the turbine has reached a certain speed, the governor pendulum, which is supplied from a permanent-magnet generator, starts to rotate and the governor is then ready to take over control. The set is synchronised automatically and can then take on load.

Fig. 7. A view of Molina dam taken when both spillways were in operation for the first time

As soon as the first jet has opened fully, an electrical contact causes the second nozzle to open; at the same time the first nozzle begins to close until they are both in the same position. Any further increase in load causes both needles to move simultaneously. If the loads drops again below 50 per cent., another contact closes one of the nozzles completely while the other opens until it gives the same output, thus increasing the hydraulic efficiency. The electrical oil pump is shut down automatically as soon as the required oil pressure is reached but starts again immediately the pressure falls for any reason below its normal value; if the oil pressure fails altogether, both jets are closed automatically, thus bringing the turbine to rest.

All the equipment for starting and stopping the sets, as well as the complex control gear, are arranged together on a switchboard in the station control room from which all operations can be supervised. Shut-down tests under various conditions and operating experience to date have shown that both machines come up fully to the guarantees given by the manufacturer in regard to output and operation. They run quietly and without vibration, thus indicating good hydraulic and mechanical design; it can therefore be expected that a high efficiency will be maintained also under practical conditions.

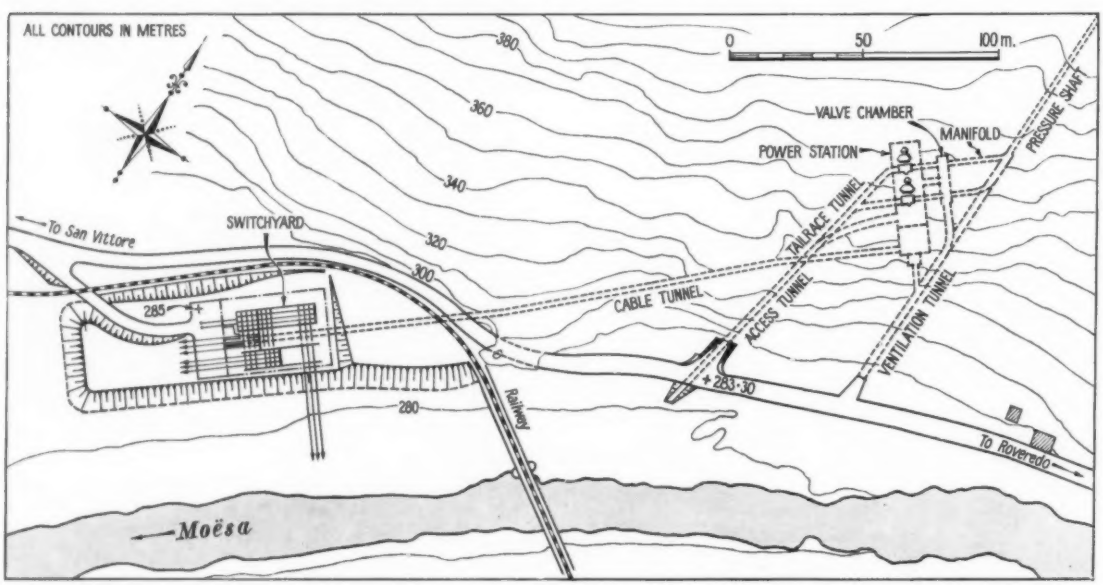


Fig. 8. Map showing location of Sassello power station and outdoor switching station

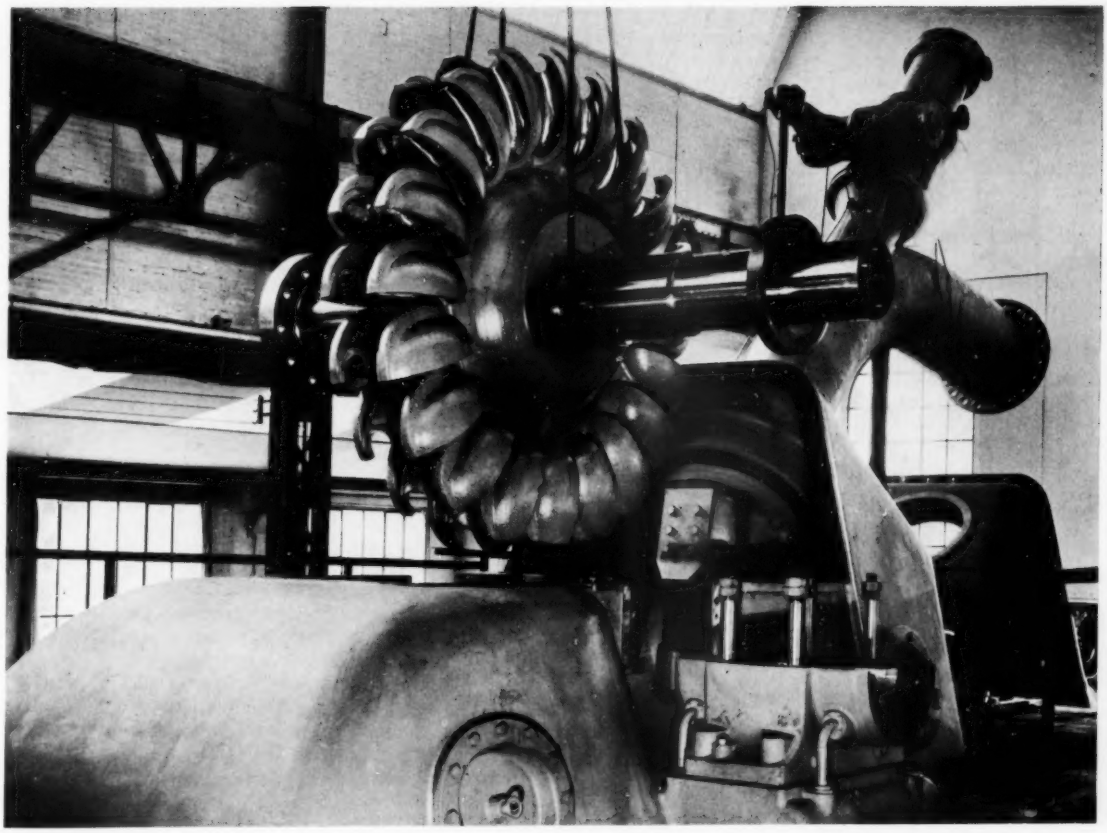


Fig. 9. One of the Vevey 14,000 h.p. Pelton turbines under construction in the maker's works

The Alternators

Each of the sets includes an alternator, a governor-pendulum generator, and an exciter (Fig. 11) which, as the remainder of the electrical equipment, were supplied by the Brown Boveri Company. Due to the location of the station below ground it proved impossible to provide natural cooling for the alternators, which are therefore of the fully enclosed type. Ventilators mounted on the rotor shaft circulate the air within the machine through coolers mounted below. In case of fire risk this circuit is automatically filled with carbon-dioxide gas so that fire is prevented at its source. The gas is stored in bottles near the alternator star point and is released when the differential relay or the alternator protection operates.

The rotor poles are solid castings of dynamo steel, thus permitting a simple and compact mechanical construction. The rotor is supported on each side by a conventional ring-lubricated bearing which contains a cooling coil fitted with a flow indicator. The set is shut down automatically when the bearing temperature becomes too high.

An extension of the main shaft carries the generator which drives the governor pendulum; its permanent-magnet poles ensure a rapid rise in output voltage so that the governor becomes fully effective well below the normal speed of the set. This rigid connection to the alternator ensures absence of hunting under all operating conditions.

The exciter is connected to the main shaft through a coupling and carries an overhung pilot exciter. The latter can control the exciter current down to zero, a feature which may be required when the alternator carries a capacitive load.

The main electrical data of the sets are as follows:

Alternator:	
Rating - - - - -	13,500 kVA at 10·5 kV, 50 c.p.s
Normal speed - - -	500 r.p.m.
Runaway speed - -	900 r.p.m.
Moment of Inertia	820 ton-ft.^{2} (74 ton-m.^{2}).
Pendulum Generator -	2·5 kVA at 110 V, 50 c.p.s
Main Exciter - - -	78 kW at 120 V.
Pilot Exciter - - -	2·8 kW at 80 V.

Substation

The alternator output is carried by a cable through a tunnel directly to the transformers of the outdoor switching station, approximately 300 yards (275 m.) from the power station.

The main power transformers are constructed in conventional three-phase units with natural cooling. The insulation of the high-voltage winding has been improved by flanging the insulating cylinder between it and the low-voltage winding at both ends. An off-load tap-changer varies the output voltage over a range of $\pm$ 5 per cent. Condenser bushings ensure control of the electrical fields and are covered by ceramic insulators. The star point of the high-voltage winding is brought out through a separate terminal so that it can later be either earthed or connected to a Petersen coil.

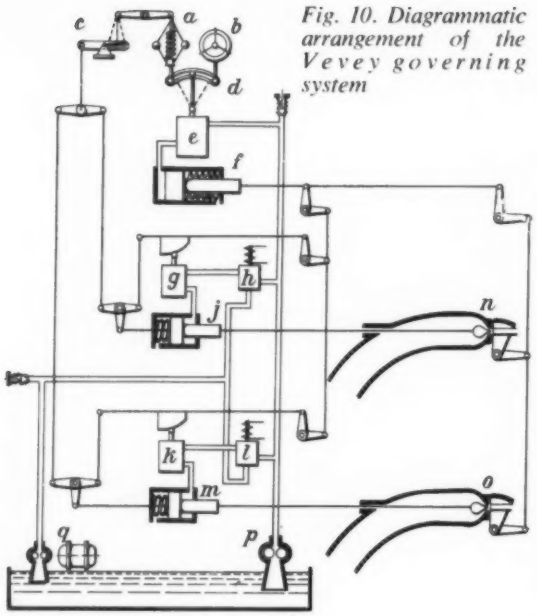


Fig. 10. Diagrammatic arrangement of the Vevey governing system

a. Velocity pendulum. *b*. Acceleration-sensitive device. *c*. Speed-droop adjustment. *d*. Adjustment of ratio between speed and acceleration response. *e*. Pilot valve. *f*. Deflector servomotor. *g*. Upper-jet pilot valve. *h*. Upper-jet control valve. *j*. Upper-jet servomotor. *k*. Lower-jet pilot valve. *l*. Lower-jet control valve. *m*. Lower-jet servomotor. *n*. Upper jet. *o*. Lower jet. *p*. Main oil pump. *q*. Starting oil pump.

The oil expansion vessel includes a breather protected by silica gel to ensure that only dry air comes in contact with the transformer oil. Internal damage is indicated by a Buchholz relay while remote-indicating thermometers provide a check on the oil temperature.

The details of the transformers are as follows:—

Rating	13,500 kVA
Voltage ratio at unity and 0·8 p.f.	53·3 10·5 / 50·8 kV 47·5
Connection	delta / star.

The two alternator-transformer units are connected to the 50 kV transmission lines through a busbar while a 2,000 kVA regulating transformer feeds the 30 kV line to the Cebbia substation of the Rhätic railway system.

An interesting feature of the substation is the circuit breakers. Both 50 and 30 kV switchgear are of the air-blast type and combine high rupturing capacity with short opening time. The circuit interruption takes place in two parts: a short travel of the moving contact to the optimum separation for arc extinction and accompanied by air blast, followed by a second movement to the final opening to give the required isolation clearance. The exhaust valve then shuts and the arc extinction chamber remains under pressure as long as the circuit breaker is in the open position. It is closed by shutting the main valve and releasing the internal pressure, when the contacts close under spring pressure.

Each switch contains a compressed-air reservoir of sufficient size for a single close-open operating cycle; air is supplied from a central compressor set. The main difference between the 30 and 50 kV breakers is the number of arc-extinction elements; the main components are identical, thus reducing the number of spare parts required. The following table gives the main data of the switchgear:

Circuit breaker size	50 kV	30 kV
Rated voltage	80 kV	30 kV
Rated current	600 A	600 A

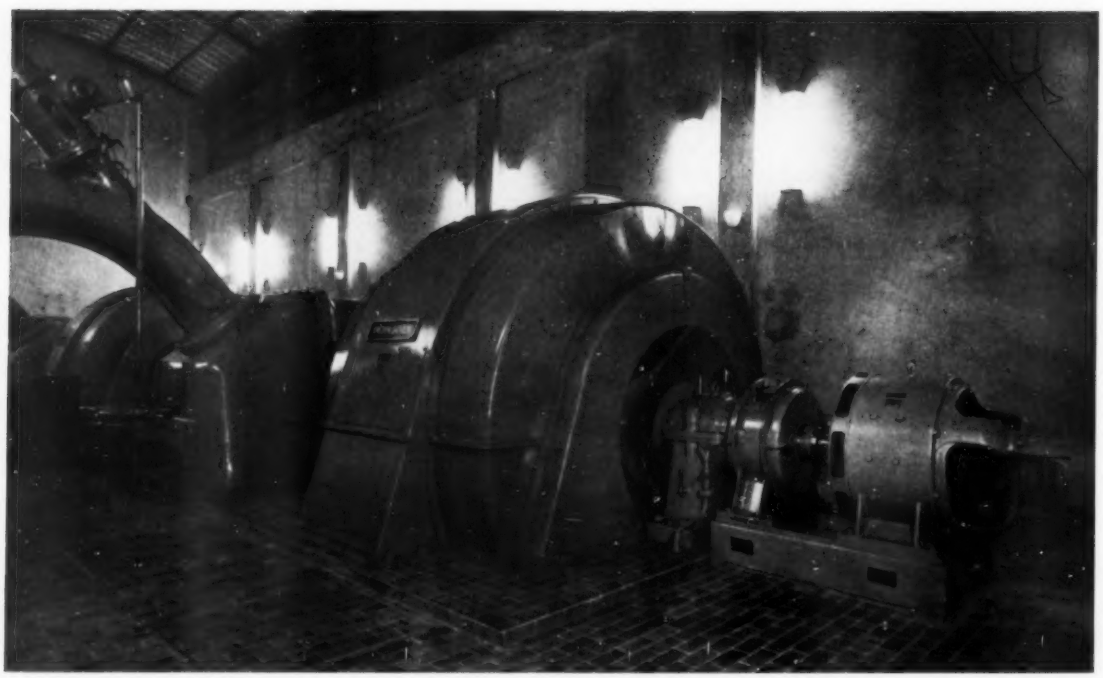


Fig. 11. Interior of Calancasca machine hall showing the Vevey/Brown-Boveri generating sets

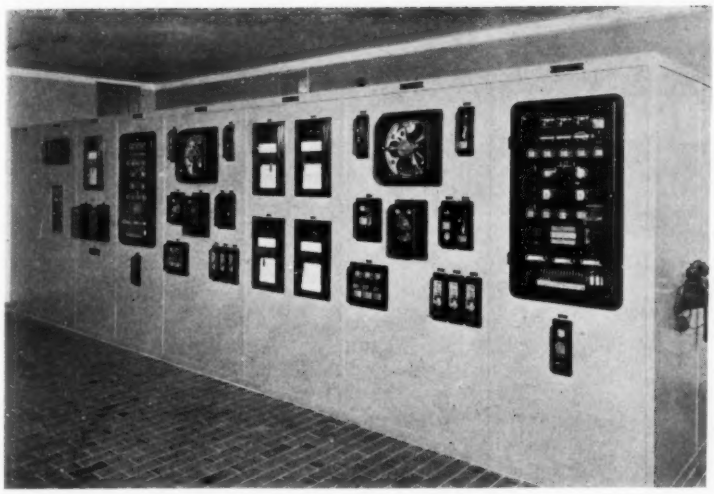


Fig. 12. Instrument, relay, and voltage regulator panel in the control room

Maximum current interrupted -	9 kA	12 kA
Closing time - - - -	0·09 sec.	0·09 sec.
Opening time - - - -	0·06 sec.	0·06 sec.
Air required for one interruption	26 cu. ft. (1,400 litres)	52 cu. ft. (700 litres)
Operating pressure - - -	220 lb. per sq. in. (15-16 atm.)	

A number of surge diverters are incorporated in the substation layout. They consist of a multiple spark gap in series with several non-linear resistance units. Application of a high voltage causes their resistance to fall, allowing the energy of a voltage surge to be dissipated to earth; the resistance then rises rapidly so that the arc does not restrike. A counter is fitted on each diverter from which the number of times it has operated can be determined.

The output of the station is transmitted mainly over the two transmission lines to the 50 kV system of the ATEL, one running to Riazzino and the other to Bodio. In addition, up to 2,000 kW can be provided to supply the valley itself and to support the Cebbia station.

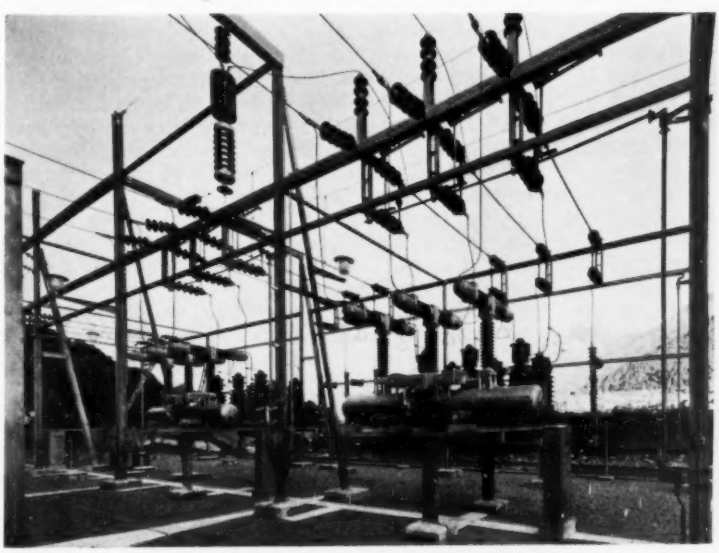


Fig. 13. 50 kV outdoor-type air-blast switchgear

Control

As has already been mentioned, the control room is located below ground in the Sassello station; since it is designed essentially for remote operation, full use could be made of all available space. The duties of the station attendant are restricted to general supervision and maintenance of the equipment. The remote control from the Piottino station provides for rapid adjustment of the power output and phase angle to suit the requirements of the ATEL distribution system. All faults, however, are indicated at the station so that the personnel on duty there can take immediate action.

The switchboard consists of two sections facing each other, one of which contains mainly the control and metering gear while the protecting and regulating equipment is mounted on the other. An overriding switch on the board is used to select one of the following control methods:—

(1) *Manual.* All operations, including valves, switchgear, synchronisation and turbine running, are controlled individually by switches on the control board. Any difference between the position of a switch and the equipment controlled by it is indicated by a lamp lighting up in the switch handle. The position of the main circuit breakers is also transmitted to the Piottino and Biaschina power stations and must be acknowledged there.

Faults are indicated by an acoustic alarm both in the station itself and in the house of the attendant. Signals mounted in the station indicate the type of fault present. A general acoustic and optical alarm is arranged in the house to call the attendant into the station.

(2) *Local automatic.* The station is again operated locally, the remote control from Piottino being blocked. The number of switching operations is very much reduced, however, since some operations are performed automatically. A single order only is required to start up the sets, but the main switchgear and the turbine valves, as well as the water intake gate, remain under separate control. Acknowledgement and fault indication are as for manual control.

(3) *Remote control.* The station is controlled from the Piottino station, with the local control gear out of action. The signal lamps on the control panel permit the station attendant to follow all switching

operations although he cannot interfere with them. Faults are still indicated by the signalling equipment but the audible alarm in the station is cut out. The presence of a fault is reported both at Piottino and at the attendant's house, but without indicating the type of fault present.

During remote control a number of operating instructions have to be transmitted from Piottino; these vary the active and reactive power, as well as the voltage and speed of the sets. In addition, a number of instrument readings, namely voltage, current, and active power per set, have to be reported back to Piottino.

The control gear includes a number of interesting automatic features:—

(a) *Voltage control.* Each alternator is fitted with an independent voltage regulator which includes a resistance preset to select the voltage on the 50 kV side of the transformer which has to be maintained constant. Before a set is connected to the busbars, this preset voltage must be adjusted to the actual busbar voltage so that reactive power surges are prevented; this is done by an impulse regulator which acts on the voltage regulator resistance. Once the circuit breaker is closed, the output current causes the voltage regulator to compensate for the voltage drop in the transformer; the regulator also shares the reactive power uniformly between the two sets.

(b) *Synchronisation.* With all three types of control the sets can be synchronised automatically; under remote control this represents of course the only method possible. The synchronising gear is mounted on the control board and compares the voltage vectors on the two sides of the circuit breaker; the speed is adjusted until they coincide, when the switch closes automatically. During local control the sets can also be synchronised manually.

(c) *30 kV line to Cebbia.* As with the 50 kV transmission lines, the voltage has to be adjusted to that of the system before the switch is closed. The impulse regulator controls in this case not the alternator excitation but the 50/30 kV regulating transformer. Again the circuit breaker can only be closed after this process has been completed. A second impulse regulator then comes into operation and adjusts the transformer to obtain a constant power factor on the 30 kV side.

Safety Devices

Since the Calancasca station is normally operated remotely from Piottino, the latest type of safety devices have been installed. They are listed in the table below, with the operations initiated by them indicated by the following numbers:—

0 signal indication only,
1 main circuit breaker tripped,
2 field circuit breaker tripped,
3 turbine safety gate closed,
4 set blocked,
5 fire-fighting equipment brought into operation.

Alternator.	Differential protection	012345
	Over-voltage protection	01234
	Over-current protection	01
	Short-circuit protection	01234
	Stator earth fault	01234
	Rotor earth fault	0
	Fire	012345
	Interruption of cooling water supply	01234
	Overheating of bearings	01234
Turbine.	Overspeed	01234
	Overheating of bearings	01234
Main transformer.	Buchholz protection	01234
	Differential protection (combined with alternator)	012345
	Overheating	0
Transmission lines.	Distance protection	01
	Earth fault	0
Regulating transformer.	Overload	01
	Overheating	0
Auxiliaries.	Interruption of d.c. supply	0
	Interruption of a.c. supply	0
Compressed air.	Low pressure in receivers	0
Airblast switchgear.	Low pressure in receivers	0
Hydraulic valves.	Water rising in valve chamber	01234
	Closing of water intake gate	01234
Voltage transformer.	Operation of fuse switches	0

The station has at its disposal four auxiliary supplies; they are not synchronised and cannot therefore be used simultaneously. A 75 kVA auxiliary transformer is connected to each alternator and a 380 V supply is obtained from the ATEL system. In addition a 50 kW diesel set is installed in the compressor house at the switching station. The auxiliary supplies are controlled from a board adjacent to the main hall and the station is switched over automatically to the next source of supply if one should fail. A mercury-arc rectifier charges the 160 Ah battery which is housed in a separate room.

The two compressors have a capacity of 630 cu. ft. (16·8 cu. m.) of air per hour at 425 lb. per sq. in. (30 atm.). They are controlled by the pressure in two air receivers through which the air is passed to reduce its moisture content.

High-frequency Telephones and Telemetering

The Calancasca station is connected to the water intake at Buseno by two telephone lines of the public network; the link to its control at Piottino and to the intermediate station of Biaschina consists of carrier-current channels over the transmission line itself. The system provides direct telephone communication between the stations and at the same time transmits both instrument readings and orders for operating the machines together with their acknowledgements.

The telemetering equipment operates on the variable audio-frequency system, using a separate channel for each alternator. The local instrument is coupled to a transducer consisting of a variable inductance. These are connected in turn to an oscillating circuit and the resulting audio-frequency is then transmitted to the remote station. There it is converted into a d.c. voltage and applied to the appropriate storage condenser which controls the current to the indicating and recording instruments. Power, voltage, and current are transmitted from Calancasca to Piottino in this way.

The remote-control gear operates over another audio-frequency channel on the impulse principle, similar to that used in telephone equipment. A single channel can carry some 30 operating instructions and 60 acknowledgments. The following orders are transmitted over this system:—

Automatic starting and stopping of the sets;
Opening circuit breakers and closing them using the paralleling equipment;
Opening and closing of the turbine valves;
Reporting back isolator positions and fault indications;
Transmitting adjustment of regulator setting;
Reporting back position of transformer tap-changer;
Stopping and starting cyclic telemetering selector;
Tranmitting orders for level changes: high-lower.
Transmitting orders for flow changes (to be installed later).

(Continued on page 57)

Third International Conference on Soil Mechanics and Foundation Engineering

The first assembly of engineers specialising in Soil Mechanics and Foundation Engineering was arranged at Cambridge, Massachusetts, in 1936. As a consequence of the war the second Conference could only be held 12 years later, in 1948, at Rotterdam. The third was held last year at Zurich and Lausanne.

AS explained in the foreword to the first volume of the Proceedings of the International Conference, the programme of the Third Congress has been jointly drawn up by the Executive Committee of the International Society of Soil Mechanics and Foundation Engineering and the Swiss Organising Committee. The two first volumes reproduce the papers submitted to the Congress together with the surveys of the General Reporters. A third volume is still to be published, which will contain the addresses at the opening and closing sessions. Some material of great interest to hydro-power developments dealt with at these sessions will therefore be published later and dealt with in this journal as soon as available.

The papers submitted to the Congress were classified in eight sections:

i. Theories and Hypotheses of General Character, Classification, Engineering Geology; General Reporter: A. Casagrande, U.S.A.
ii. Laboratory Investigations, Including Compaction Tests, Improvements of Soil Properties; General Reporter: E. C. W. A. Geuze, Netherlands.
iii. Field Investigations, Technique of Field Observations including Compaction Control, Soil Stabilisation; General Reporter: W. Y. Turnbull, U.S.A.
iv. Foundations of Buildings and Dams, Bearing Capacity, Settlement Observations, Regional Subsidences; General Reporter: M. Buisson, France.
v. Piles and Pile Foundations, Settlements of Pile Foundations; General Reporter: R. B. Peck, U.S.A.
vi. Roads, Runways, Airports and their Foundations; General Reporter: Sp. Y. Buchanan, U.S.A.
vii. Earth Pressure, Retaining Walls, Tunnels and Strutted Excavations; General Reporter: A. W. Skempton, England.
viii. Stability and Deformation of Slopes, Earth Dams and Ground Water Problems; General Reporter: L. Bjerrum, Norway.

There is some difficulty in selection of a few papers for a survey in this journal as there is so much of interest to hydro-power engineers. General papers by Habib and Puyo (France) (I.7) on "Evaluation of Transverse Stresses During Consolidation," or by M. J. Youssef (Egypt) (I.19) on "Relation between the Mean Grain-Size, the Size Factor and the Optimum Moisture Content of Compacted Soils," classified in section I, may be of great interest to a dam designer. So may the paper by Hansen (Denmark) on "A General Earth Pressure Theory" (VII.5), and many papers of section III, especially paper 3 by F. J. Davis, U.S.A., on "Quality Control of Earth Embankments," or by Haefeli and Fehlmann (Switzerland) on "A Combined Penetration Process for Exploration of the Foundation Soil." But so also, in the same section, are the papers of Lewis (England) on "Soil Compaction"; and of Süsstrunk (Switzerland) on "Seismic Methods of Subsoil Investigation."

In Section IV, some papers are specifically dedicated to problems of water-power engineering. Bellier, Frey and Marchand have measured the "Compressibility of the Foundation Rock under Supports of Dams." Their paper is a comparative study, carried out on two arch dams, of the relative strains of the foundation rock and the adjacent concrete. The measurements were made by means of strain meters (vibrating string extensometers), some of which were placed in the concrete of the abutment, and the others in holes drilled in the rock, in line with those in the abutment. On the whole, the strains of the rock were in the same direction as those in the adjacent concrete (from 5 to 13 times more—the absolute value of Young's modulus is not given). At certain points, strains occurred in the rock, while the adjacent concrete showed none. This could be explained by the action of phenomena of plasticity, or by the existence, in the rock itself, of a region which is particularly sensitive to strain, the dam abutting in this case on the surrounding zones. The temperature effect on strain measurements was eliminated by strain measurements on blocks of concrete submitted to no stresses. In paper IV/17, Lane and Occhipinti (U.S.A.) report on "The Movement Analysis at Garrison Dam, North Dakota." Garrison dam is a multipurpose project now under construction by the Corps of Engineers, involving some 70 million cubic yards of rolled earth embankment and 90 million cubic yards of excavation. Major structures occur at the gate-controlled chute spillway on the left bank, and on the right bank at an intake structure, eight tunnels and a power house.

Although the clay-shale at Garrison dam is heavily preconsolidated the load changes are so large, with excavation up to 250 ft., as to result in major movement. In fact, substantial movements from both consolidation and elasticity-rebounds up to 2 feet have been measured from excavation unloading to a depth of about 175 ft. About 100 gauges were installed in borings in regions of the various structures and were preferably placed prior to starting excavation.

To ascertain the reduction of movement with depth several gauges were placed at depths ranging from 5 to 150 ft. below excavation grade. Measurements indicated that about half of the movement occurs in the upper 100 ft. Due to the importance of these movements, articulated structures on shallow foundations were adopted.

Section VII concerns Earth Pressure, Retaining Walls, Tunnels and Pits in Soils. Several papers submitted to this section are of great interest for hydro-power structures. So is also the report of the General Reporter of this section, Prof. A. W. Skempton, from Imperial College, London.

In a paper (VII/1) on "Measurements of Moduli of Elasticity and their Application to Design," Mr. P. Bernard from Casablanca, Morocco, describes tests which were carried out on many types of rock encountered when driving a tunnel 17 km. in length. Three types of tests were carried out: Plate bearing tests by jack on rocks from very soft sandstone to very compact quartzites;

Tests in-situ in galleries with or without linings, the diametrical strain being measured by means of acoustic cells;

Tests in-situ on the efficiency of consolidation by cement grouting in fissured rocks.

It was possible to classify the rocks in three categories: (a) compact rocks not subject to considerable strain; (b) fissured rocks with high plastic strains; (c) soft rocks with lateral failure under low pressure. The modulus of deformations is always greater when the load applied is normal to the strata than when it is parallel to them (a result which is well known from earlier measurements made in Switzerland). The values for Young's modulus varied from 66,000 kg./cm² to 190,000 kg./cm² for schists to 250,000 kg./cm² and 455,000 kg./cm² for quartzites. For lined tunnels in sandstone the values of the modulus were as low as 2,000 to 26,000 kg./cm². (These figures are also in agreement with measurements made in Italy and Switzerland.)

Great importance is to be given to the tests with cement grouting (measurements of stresses in lining during and afer injection, determination of strain under loaded galleries and jack tests before and after grouting).

The tests show that: The lining contracts during the grouting process to a great extent permanently; the strains under loading are reduced and are equalised in the various planes; the deformations obtained in the first tests were almost eliminated by grouting.

Tests in schists were carried out with grouting pressures of 30 kg./cm² (about 175 kg. of cement per square metre) with the result that the modulus of elasticity was improved from 40,000 kg./cm² or 57,000 kg./cm² to 100,000 kg./cm² or even 236,000 kg./cm². Tests in sandstones and marl showed little success. It is likely that grouting is efficient in hard fissured rock only where the fissures are closed by the grout.

The problem of the modulus of elasticity of rocks is also dealt with in the paper of A. Mayer, the well-known manager of the Laboratoire du Bâtiment et des Travaux Publics, Paris. He summarises earlier papers published by members of the laboratory staff (Habib, Marchand) since the Congress of Rotterdam. Some of the measurements described in these papers were carried out with hydraulic jacks giving the modulus of elasticity. Other methods give directly the strain and stresses in rock (Tincelin). This method is for measuring stresses around a cavity in rock by means of a flat jack of the Freyssinet type. The theory elaborated by Tincelin in conjunction with the tests he carried out in iron-ore mines is said to be very similar to the well-known theory of Terzachi and Richart. The bibliography at the end of the paper mentions (without discussing them) the important papers by Rousselier and Talobre of Electricité de France. It would have been highly desirable for the opinion of the engineers of Electricité de France to be discussed at Zurich, as the material and information collected—but still not published—by this important office surely is of great value.

A second method by L'Hermite and Chefdeville utilises acoustic methods for determining the velocity of sound in rock. In order to give coherent results this method should be applied in rock with no fissures.

The second part of the paper by A. Mayer describes a method by Delarue for computing the thickness of the lining of a pressure tunnel in rock. The author indicates how such a lining can be precompressed by grouting with expansive mortar, thus permitting an important reduction of the thickness of the lining and the weight of reinforcement bars. (The similar method by the Austrian engineer Kiesser has not been discussed by the Congress.)

In the field of rock tunnelling Y. Caille and R. Barbedette in paper VII/2 give an account of a technique by which the construction of a tunnel in fissured water-bearing rock can be expedited by forming an "umbrella" or hood of grouted rock ahead of excavation. Two typical current examples are given:

Ait Ouarda-Afourer tunnel (Oued El Abid project, Morocco): The downstream attack, totally stopped by a water inrush of 200 l/sec. under a pressure of 15 kg./cm², could be resumed under the protection of successive grouting umbrellas, each 90 m. in length. At the present time, more than 1,100 m. are being driven in this manner at a rate which reached 4 m. per day in certain sections.

Intake tunnel of the lac d'Issarlis (Montprezat project, Ardèche, France): Work on the intake tunnel was also stopped, at approximately 80 m. from the lake, by an inrush of water up to 200 l/sec. The preliminary grouting method is being used with complete success; judiciously adapted to the case in question, it will make it possible to come near enough to the lake for blasting out.

A similar grouting technique was used some two years ago for driving the 14 km. long Malgovert tunnel through about 150 m. of severely crushed and water-bearing quartzite. This job is not mentioned by the authors, who record other jobs in Japan, Algeria and France (Pralognan).

The different papers submitted to Section VII are commented upon by the General Reporter Prof. Skempton (London) who in addition summarises the well-known paper by Terzaghi and Richart on stresses in rock surrounding tunnels or cavities. The theory of elasticity was used to compute the stresses and numerical solutions are presented for circular and elliptical tunnels and for spherical and spheroidal cavities. It is shown that the stresses depend to a very marked degree on the state of stress in the rock prior to excavation.

The Reisseck-Kreuzeck Development

Dr. Erwin Königshofer describes a development, now partially constructed, which will enable Austria to increase her exchange of power with Italy. It will comprise one storage and two non-storage schemes, and will furnish a high proportion of valuable winter power. The ultimate capacity envisaged is 132 MW.

AS a result of a request submitted to the World Bank for a credit to facilitate the exchange of power between Austria and Italy a contract was entered into by the power corporations of both countries. This contract was agreed upon in 1951 and provides for a modest supply of energy in the early stages, but once the scheme, now under construction, is completed, an exchange of electric power on a large scale will be rendered possible.

This fact in itself gives special interest to the Reisseck-Kreuzeck scheme, but the plant is also full of interest from the technical standpoint. The electrified Tauern railway connecting the federal provinces of Salzburg and Carinthia via Bad Gastein traverses the valley of the river Möll, a tributary of the Drau. The Möll valley is situated between the Reisseck mountain range in the north-east and the Kreuzeck in the south-west. These mountains are very high, and numerous tributaries flow down their rocky slopes to join the Möll. In the Reisseck range there are several small lakes at an elevation of between 2,390 to 2,283·8 m. above sea level—the Hochalpensee, Radlsee, Kleiner Mühldorfersee and the Grosser Mühldorfersee. The horizontal distance between these lakes and the Möll valley is only about 3 to 4 km., offering the impressive head of 1,770 m. between the lakes and the floor of the Möll valley.

The drainage system between these two ranges has been a matter of hydrotechnical study for more than two decades with the object of utilising the lakes as storage basins for power production. Work was begun on the Reisseck-Kreuzeck scheme in 1947 but progress has been greatly retarded because of financial restrictions. The project provides for water intakes at three different altitudes, with the turbo-generators supplied from these three sources centralised in a single power house at Kolbnitz, situated on the left bank of the river Möll at an elevation of 606·5 m.

Reisseck Development

Part of the development in the Reisseck range will consist of a storage scheme utilising all four of the natural lakes, their capacity having been greatly augmented by the erection of dams. Fig. 2 gives an exploded cross section to show the relative position of the lakes and the system of tunnels which converges the water on the central power station. These works will give rise to a utilisable gross head of 1,771·3 m., believed to be the highest in the world.

In addition, the Reisseck development will include a non-storage scheme utilising the run-of-river flows of the Riekenbach, Zwenbergerbach, Kapponigbach and Mühldorferbach streams, all of which flow into the Möll river. The intake for this scheme is now under construction. It is situated at an elevation of 1,290 m., and is fed by one tunnel conveying the waters of the Kapponigbach, Zwenbergerbach and Riekenbach and a second tunnel those of the Mühldorferbach. The Mühldorferbach waters are held in a daily storage basin on the Gondelwiese at an elevation of 1,288·5 m. before they enter the pressure tunnel leading to the intake.

Adjacent to the intake are located a surge tank and a valve chamber, and from the intake a penstock descends to the appropriate turbines in the Kolbnitz power station, the gross head on these turbines being 678·5 m.

Surplus water from the streams feeding the non-storage plant can be pumped into the reservoirs of the storage plant, and for this purpose a pump house has been erected at 1,110 m. above sea level, where two pumps are located, driven by 8,200 h.p. synchronous motors. Later investigations have also shown that water from the adjoining catchment area—from the Gössbach, a tributary of the Malta—can also be utilised (Fig. 1). This water can be conducted into a daily storage basin located at 1,553 m. above sea level (Fig. 2), and the resulting head of 235 m. between this basin and the pressure tunnel of the non-storage plant can be utilised in a power station of 8 MW capacity.

Kreuzeck Development

In the Kreuzeck range there will be a non-storage scheme utilising the waters of five streams and their tributaries, which fall partly into the Möll and partly into the Drau (see Fig. 1). The intake for this scheme will be constructed at a height of 1,194 m. on the Rosswiese where there will be a weekly storage basin. The gross head on the corresponding turbines in the Kolbnitz power station will be 587·5 m.

Present Progress

As will be seen from this short description, the construction sites and the locations for the quarrying and storage of materials are far removed from the railway and at considerably differing altitudes. Besides shelter for the workers, extensive equipment has been provided for the opening of construction sites. An inclined hoist 3,580 m. in length, has been partially erected along the penstock track to an altitude of 2,335 m. above sea level, and auxiliary hoists, funiculars and rails have also been erected. The equipment already provided will enable work to be carried out on every construction site and will render it possible for the dams at the four small lakes to be erected at any time.

The following works of the project we have briefly sketched are already accomplished: the intake of the Mühldorferbach and Riekenbach streams, the valve

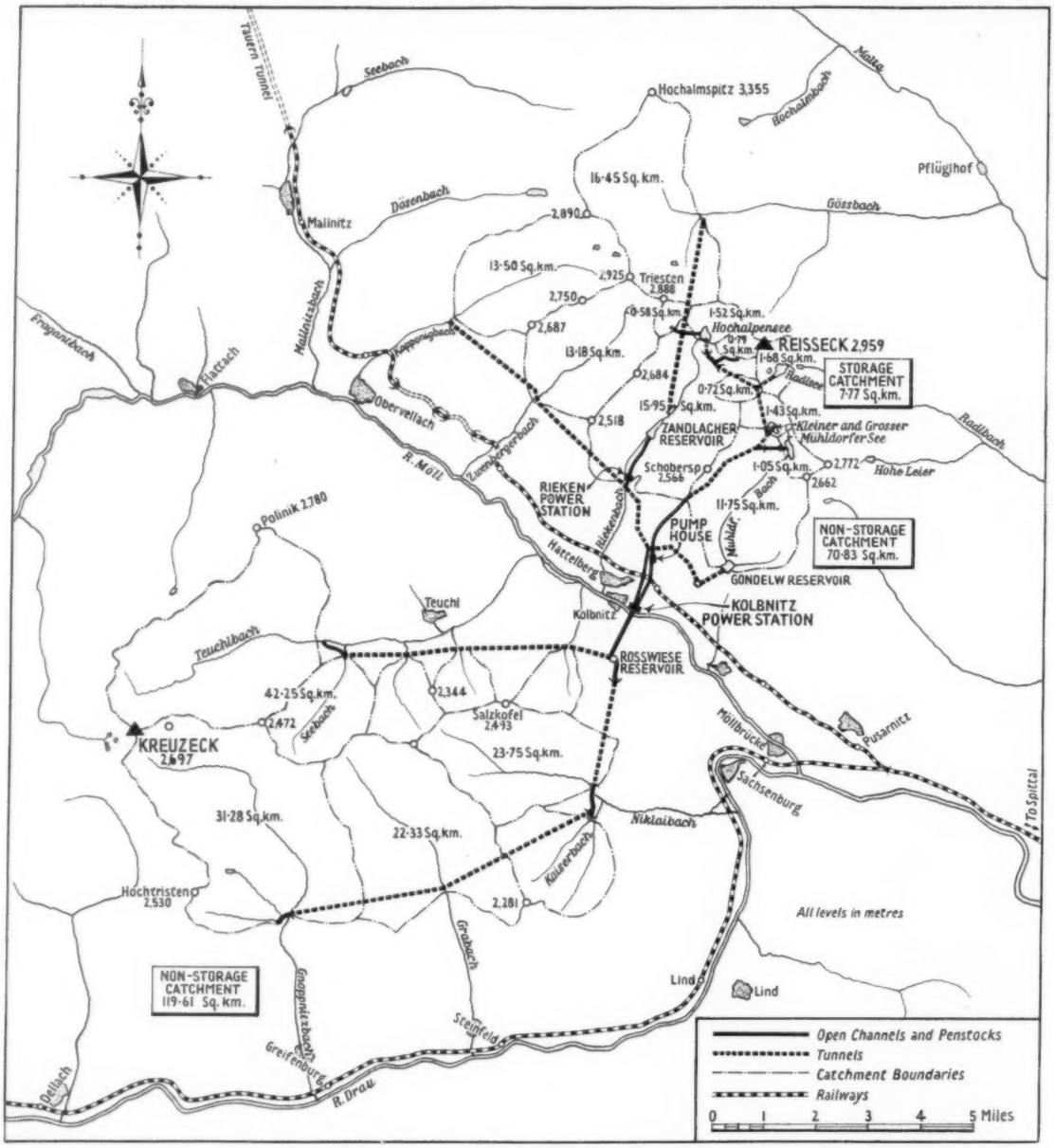


Fig. 1. Map of the Reisseck-Kreuzeck development

chamber, the penstock of the Reisseck non-storage plant, and the intake channel of the lake Grosser Mühldorfersee. The Kolbnitz power station is partially completed, so that the waters of the Mühldorferbach and the Riekenbach can be utilised in two sets of 10,200 and 28,500 h.p. capacity respectively. The generator voltage of 10 kV will be transformed to 20 kV for supplying the sites, and to 110 kV for supply to the Austrian power grid system.

Capacity

On the assumption that a loan will be granted by the World Bank to enable this scheme to be completed, the energy balance will read as follows:

The storage plant will have a maximum capacity of 60 MW, yielding yearly (in a normal year) an average output of 72 million kWh. This production will be effected exclusively during the winter months.

The Reisseck non-storage plant including the remote-controlled intermediate power station at Rieken will comprise 32 MW and produce 132·4 million kWh, 33 million kWh being produced during the winter months. In the Kreuzeck non-storage plant 40 MW could be installed, producing annually 153 million kWh, 43·6 million kWh of which would be generated in winter.

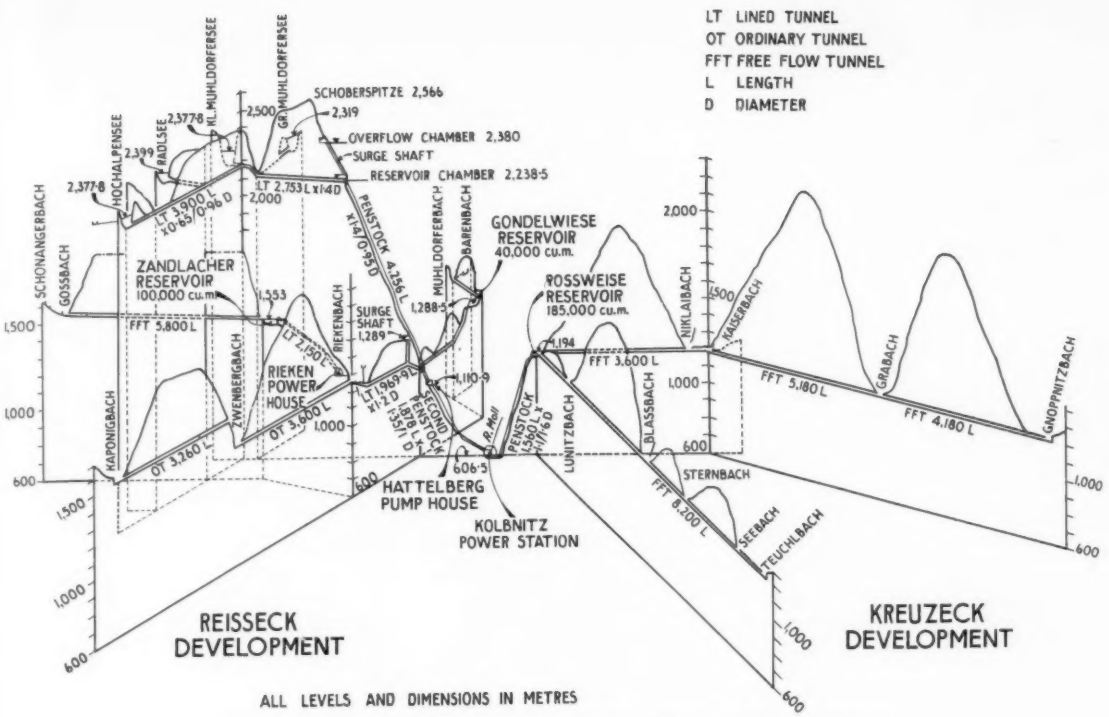


Fig. 2. Profile diagram of the Reisseck-Kreuzeck development

Taking into consideration the loss of pumped water in the non-storage plants, we can sum up as follows:

The seven generating units of the completed plant will aggregate 132 MW, producing annually 348 million kWh (pumping energy deducted), 146·3 million of which will be generated in winter and 201·7 million kWh in summer.

These figures reveal the high economic value of the plant, and there appears every reason to hope that the request for credit will be settled favourably.

From page 52

Two additional audio-frequency channels are provided for raising and lowering the power and voltage-regulator settings, thus allowing these instructions to be transmitted without delay.

A further but somewhat simpler control scheme is in operation between Calancasca station and the water intake at Buseno; it controls the intake gate and reports back the level of the water. The remote level indication at both the summer and winter intakes also makes use of the impulse principle. When the system is first started up, the indicator is set manually to the correct water level. Every change in level by 2 in. (5 cm.) produces positive or negative signals in the transmitter which are then carried over the remote control channel as a distinct combination of impulses. At the control room they are converted into positive and negative d.c. impulses which operate the motor of the level indicator.

When the summer intake at Buseno is in use, cams actuated by a float operate the "higher" and "lower" contacts. In the winter reservoir, however, it proved impossible to provide a float-type indicator. The water level there is measured by a pressure balance in which the static head acts on a weighbeam through a piston. This force is balanced by a moving weight which is traversed along by a motor until equilibrium is obtained. Suitable contacts on the motor shaft provide the required indication of the water-level changes.

This carrier-current telephone and telecontrol scheme allows Calancasca station to be operated from the central control room at Piottino, while at the same time indicating the position of its equipment at Biaschina. The system utilises the high-voltage transmission line which had to be provided in any case, thus combining low cost with reliability.

NOTE. This description is based on an article which appeared in German in *Technische Rundschau*, Nos. 14-16a, 1952. Fig. 9 was supplied by Ateliers de Constructions Mécaniques de Vevey and all other photographs by Electro-Watt Electrical and Industrial Management Co. Ltd.

Kent KU Flow Meter. In our article on this new meter in our December 1953 issue some confusion arose in the description of the range of mercury chambers and the test pressures to which they are subjected. Forged-steel mercury chambers are available for a range of six maximum differential heads, for 25, 50, 100, 200, 400 and 600 in. water gauge (air-on-mercury basis). The 25 in. head chamber is designed for a maximum working pressure of 250 lb. per sq. in. and all other chambers for a maximum working pressure of 2,000 lb. per sq. in. All chambers are tested to twice their maximum working pressure.

Construction Plant of the Grande Dixence Dam

Brief particulars are given of this huge construction plant which has been planned to place an average of 4,300 cu. m. of concrete per day

IF we consider that the Grande Dixence dam alone will absorb a volume of concrete of no less than 5·7 million cu. m., it is obvious that a development of this scope, on the first stage of which work started in 1950, involves building facilities on a huge scale. The construction plant provided, indeed, has been planned to place a daily average of 4,300 cu. m. of concrete at the rate of 300 cu. m. per hour, which means a peak performance of 6,000 cu. m. in two ten-hour shifts a day; it is expected that the 1·7 million cu. m. of the first stage will be placed in three runs of 150 days each.

Access to the various construction sites from the Rhone valley is ensured by a new road, 5·5 km. in length, connecting the old Dixence road, at Motôt, to Blava on the left bank of the river, the centre for the batching and mixing plant. In addition, two 17·5 km. cableways are provided for carrying 50 tons of cement per hour from the Chandoline railway to Blava; and a final means of access consists of a 1·8 km. cable railway running in a tunnel between Blava (el. 2,350 m.) and the Prafleuri moraine (el. 2,600 to 2,800 m.)—a deposit from which the aggregate supplies are drawn.

After extraction by five power shovels, the morainal material is conveyed by heavy lorries to a 42-65 in. Allis-Chalmer crusher with an output of 800 tons per hour and capable of taking 1·5 × 1·0 m. blocks, delivering up to 220 mm. in size. This is taken by a belt conveyor to the silos of eight primary crushers with an output of 50 cu. m. per hour of ballast 0-120 mm. Lumps of over 120 mm. are dealt with in two rotary crushers placed immediately after the jaw crushers, which can also modify the granulometric curve of the material submitted to primary crushing. A 900 mm. wide belt conveyor, divided into six sections, and 1·6 km. in total length, transfers the 0-120 mm. material through the tunnel to the Blava dump. A branch of the Prafleuri-Blava conveyor delivers to a reserve dump of 130,000 cu. m. which feeds the Blava dump when required. This reserve dump fulfils a double purpose; on the one hand, it enables actual concreting to be placed in the very beginning of the working season (May), when extraction at the Prafleuri moraine is practically impossible, owing to its high altitude; on the other hand, it acts as a standby to secure continuity of work in the case of a breakdown in the Prafleuri-Blava conveying system.

Close to the 22,000 cu. m. dump, an extensive installation with additional sorting, washing, secondary crushing and grinding equipment, produces from the 120 mm. material all the necessary sand and gravel which is subsequently stored in five silos 15 m. in diameter by 20 m. in height, with a useful volume of 17,000 cu. m. The sorted material ready for use is divided into four sizes: 0-3, 3-10, 10-40 and 40-120 mm. These silos empty into two sets of belt conveyors by means of chutes automatically controlled from the two batching towers. The cement, filled at the factory into steel containers, is brought from the Sion railway station by means of the two Chandoline-Blava cableways to two 900 ton silos, from which a Fuller pump dispatches it to the batching towers at the rate of 40 tons per hour. (Note: This mode of cement transport —T.M. or Transports Mécanisés—was the subject of an illustrated article in our issue of May 1952, p. 177.)

The concrete leaving the hoppers of the batching towers is conveyed in four 6·5 cu. m. trailers to the loading point of the cableway cranes, and is distributed to the pouring points by means of four cableways 870 m. in span, the 72 mm. diameter full-lock carrier cables of which have a common anchorage on the left bank at about 2,415 m.; the anchoring point of each cableway crane on the right bank consists of a trolley moving on a 300 m. arc-shaped track common to the four cranes; as this track is laid at a gradient of 35 per cent. the trolleys are fitted with toothed racks. The 6·5 cu. m. (15 ton load) skips move on the cables at the rate of 5·25 m. per sec., and the hoisting speed is 2·5 m. per sec.; they are of the bottom-discharge type and empty automatically

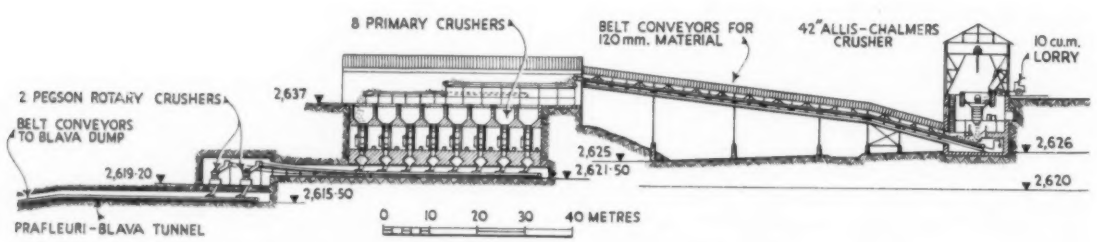


Fig. 1. Longitudinal section through the primary crushing plant

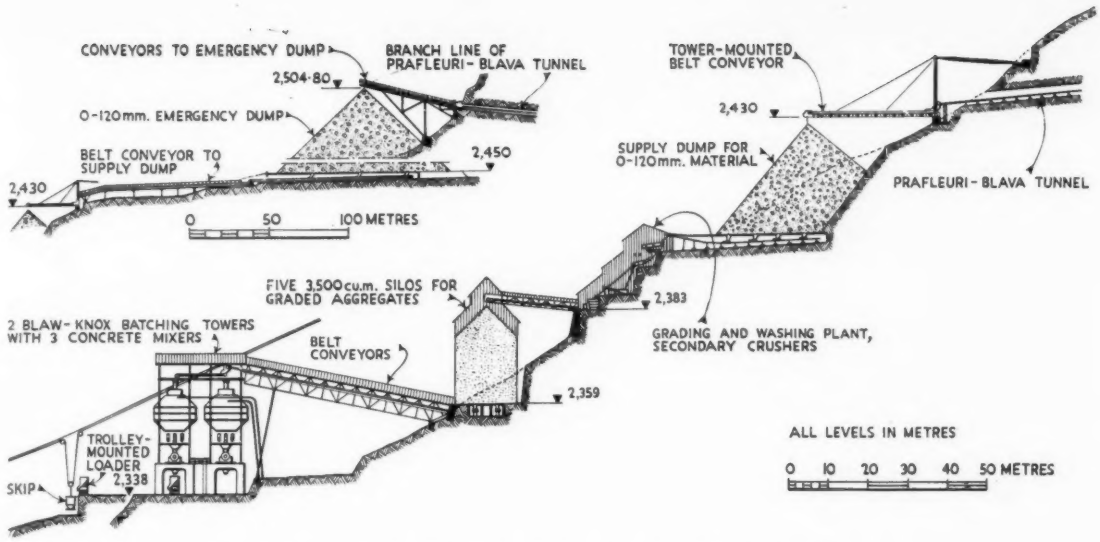


Fig. 2. Grading, secondary crushing, and concrete-mixing plant

by means of an oil-pressure control. A Ward-Leonard set supplies the necessary direct current to the driving motors of the cableways.

The aggregate electric power installed at the construction plant is about 25,000 kVA, with 20 kV supply in the construction plant itself, and a 20 kV as well as a 65 kV overhead line connecting Chandoline with the plant. Dwelling accommodation is provided for 200 men at Prafleuri, and 800 at Blava and at the dam site. A pumping plant with a 300 litres per second capacity and a 200 m. lift conveys the necessary water from the existing lake to a reservoir at Blava.

Work on the Grande Dixence construction plant was scheduled to enable concreting to start at the beginning of August 1953, so as to complete the first stage in the autumn of 1956, when the crest of the dam will have reached the 2·262 m. level. To carry the dam to its final level at 2,365 m. with the help of all the building facilities provided, it is estimated that about 1,400 work hours will be required.

The above description of the Grande Dixence Construction Plant is drawn from the article by M. J. Desmeules, Chief Engineer of the Grande Dixence Co., published in the issue of June 13, 1953, of the *Bulletin Technique de la Suisse Romande*.

Book Review

Wasserkraftanlagen (Water-power plants), by Alfred Rauch, chief engineer J. M. Voith Works. Published by Franckh'sche Verlagshandlung, Pfizerstrasse 5-7, (14a) Stuttgart-0, 8 in. by 6 in., 254 pp., 226 ff. Price in Germany, half-cloth bound, DM.14.00.

In the author's own words, the main purpose of this handbook is to provide owners of small power plants with information which will enable them to improve the efficiency of their existing plants. The book is therefore written almost exclusively from the practical standpoint, theoretical considerations being restricted to a minimum, and there are no more than two or three mathematical formulae and a few easily comprehensible graphs. General data are condensed in an initial section of no more than two pages; sections II to IV deal with the various types and designs of water turbines, their governing systems, efficiency, applications, and mode of installation; sections V and VI describe the equipment of surge chambers and turbine pits, and the various patterns of drive, respectively. Examples of the reconstruction or transformation of obsolete plants appear in section VII; section VIII deals with weirs and barrages, section IX with pipes and pipelines, and section X is devoted to the deficiencies occurring in various parts of a water-power plant from the intake to the turbines and waterwheels. The Statutory Regulations printed in section XI are followed by very useful instructions applying to the economical utilisation of power water, as well as to flood control, freezing of canals, ice control, protection of conduits from frost hazards, operation of penstocks, control of runaway speed, etc. Section XII deals briefly with water-flow measurements and the methods applied to head calculation. The final section contains tables which give the diameter of shafts and their weight per metre in kg. according to various ratios of power output to r.p.m., and is followed by an index. On the whole, small water-power plants in this country do not widely differ from similar German plants, so that this handbook should be very useful to British operators who command a fairly good knowledge of German; in this respect, the excellent line illustrations and their legends should prove particularly helpful.

Order for Aluminium Conductor. A Canadian order worth about $\$\frac{3}{4}$ million has been obtained by Aluminium Wire & Cable Co. Ltd. for the supply of steel-cored aluminium conductor to the British Columbia Electric Railway Co. Ltd. for delivery during the first half of 1954.

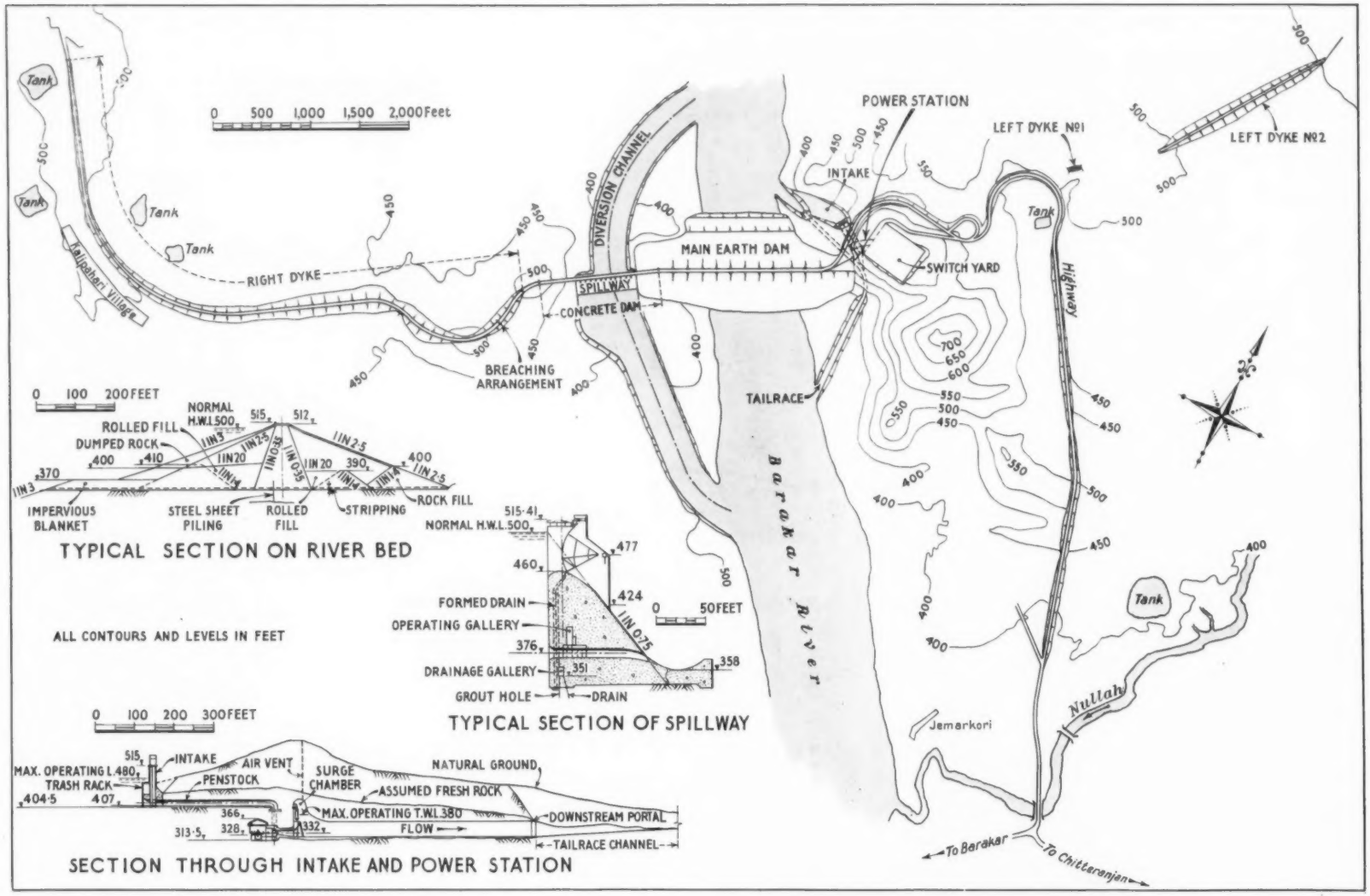


Fig. 18. Plan and cross sections of Maithon dam

Fig. 19. Scale model of Maithon dam

Damodar Valley Project

This concluding article describes the Maithon and Panchet Hill dams, and the Durgapur barrage, and includes some particulars of the DVC power system

PART THREE

ALL the seven dams proposed in the Damodar Valley development are sited above the confluence of the Barakar river with the Damodar, and Maithon is the last project on the Barakar river. The dam, a composite structure—partly concrete, partly earthen—will be about 160 ft. high and has been designed primarily for flood control. The reservoir will provide a total controlled storage capacity of 1·1 million acre feet, which is about one fourth of the total capacity to be provided by the seven reservoirs taken together. The generating station will have an installed capacity of 40,000 kW and will produce 164 million kWh of energy per year, of which just over a half will be primary energy available throughout the year and the rest available only during the monsoon.

Maithon is one of the biggest dams under the scheme and its construction is probably the most highly mechanised of all similar projects in the valley. The project consists of (a) one earth dam about 160 ft. high by 2,200 ft. long, one diversion tunnel about 1,300 sq. ft. in area and 1,110 ft. long, one diversion channel approximately 350 ft. wide, 80 ft. deep and 4,000 ft. long; (b) one gravity-type concrete spillway about 600 ft. long flanked by concrete non-overflow sections 670 ft. long; (c) earth dykes about 50 and 30 ft. high and approximately 7,000 and 2,000 ft. long on right and left banks respectively (Fig. 18). The quantities involved have been estimated as excavation (common), 2·6 million cu. yards; excavation (rock, open cut), 0·973 million cu. yards; excavation (rock, tunnels), 60,000 cu. yards; rolled fill, 4·1 million cu. yards; concrete, 0·542 million cu. yards, and steel about 2,000 tons.

The main earth dam is designed to make full use of the material excavated from the diversion cut. It will consist of an impervious rolled-fill core with upstream and downstream sections of impervious, semi-

Fig. 20. Maithon earth embankment from left bank

pervious or pervious rolled fill. A dumped rockfill will be placed along the upstream and downstream toes. Dumped riprap will be placed on the upstream and downstream slopes of the embankment. The earth dykes will consist of impervious rolled fill with dumped riprap on the upstream and downstream slopes. The spillway, a concrete gravity-type structure, is designed for a discharge of 510,000 cusecs, and in addition two sluices will dispose of 82,000 cusecs. Also, to ensure the safety of the structure, it being an earthen dam, a fuse plug or an emergency spillway is incorporated into the design. The spillway is fitted with twelve tainter gates 41 ft. wide by 40 ft. high operated with individual hoists. The total storage at the top of the gates is 1·1 million acre feet of which 725,000 acre feet will be controlled flood storage. The average tailwater level is 150 ft. below the crest of the gates, the maximum gross head at the turbines being 154 ft. and the minimum just before the monsoon 85 ft.

Construction on the main earth dam on the river bed began in December 1952 after the completion of the diversion tunnel. The construction is scheduled for a two-season operation. A diversion channel was being cut on the right bank, all the material being placed in the main earth dam. The operation covers the critical period between the monsoons and the cut was to be finished before June 1953. The concrete spillway will come in for the next operation to commence after the 1953 monsoon and is to be completed by June 1954. It involves the placing of 450,000 cu. yards of concrete in a period of eight to ten months. A batching plant with a capacity of 4,000 cu. yards per day and an aggregate plant with crushers, screens and belt conveyors have been ordered and are being erected. All the work is being done departmentally except the diversion dam which was let out to Hindustan Construction Limited, of Bombay.

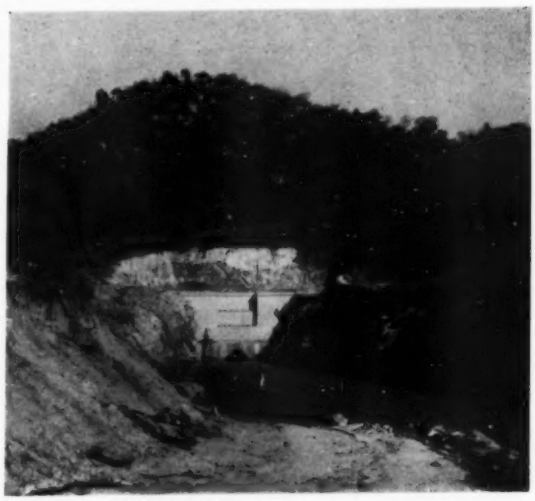


Fig. 21. Maithon diversion tunnel

Fig. 22. Concreting in progress at Durgapur barrage

Panchet Hill Dam and Durgapur Barrage

The last of the DVC dams on the Damodar, Panchet Hill, like its counterpart Maithon on the Barakar, is primarily concerned with flood control, and the two together, with some help from the upper reservoirs, will give the lower valley full protection against the worst floods hitherto recorded. In design, too, Panchet Hill will be similar to Maithon, and while 100 million kWh of power will be generated from its 40,000 kW plant, the area it will serve with perennial irrigation will be 680,000 acres as against 270,000 acres to derive benefit from Maithon. The 135 ft. high dam will impound a reservoir with a maximum storage volume of 1·2 million acre feet, of which 881,000 acre feet will be controlled flood storage. The concrete spillway will be 775 ft. long with 200 ft. concrete abutments on either side. The main earth dam will be 1,800 ft. long and the earth dikes about 18,000 ft. long. The overflow spillway will have a discharge capacity of 638,000 cusecs. The preliminary designs of the dam are ready; in fact, they are very similar to those of Maithon dam. Work on the diversion cut has already started but work on the main dam will await the release of machinery from the Maithon project for transfer to Panchet Hill. The dam is scheduled for completion in 1955.

Fig. 23. Concrete mixers for Durgapur barrage

The water discharged from the four dams—Tilaiya, Konar, Maithon and Panchet Hill—all of which constitute the first phase of the DVC scheme, will be diverted into 1,800 miles of canals and distributaries by a barrage about 2,500 ft. long and 35 ft. high, sited at Durgapur, below the confluence of the Damodar and the Barakar. The barrage will thus be the main headworks for the irrigation system in the valley and will also act as the controlling reservoir for the navigation canal. The whole project is linked with the Maithon and Panchet Hill dams and is scheduled for completion by the time these will be ready, that is, by 1955. Digging of canals has already commenced and concreting on the barrage has also begun. Table IV gives a statistical summary of the Panchet Hill and Maithon projects.

Fig. 24. Transporting concrete for Durgapur barrage by a human chain

Power System

According to an estimate of the Central Technical Power Board (to which reference has been made in the first article), the total installed electrical generating capacity in the region is about 391,600 kW, of which just under 270,000 kW cater for industrial loads. Only a portion of the existing plant would remain serviceable for regular supply of power after commencement of supply from the D.V.C. According to the Report, ". . . in the case of town installations, the installed capacity has been found inadequate, conditions of plant unsatisfactory, and working uneconomical. Many of the colliery power stations are likely to close down gradually and the generating plant installed in the major industries is not capable of coping with the increasing demand on the expansion of industries." As a result of the load survey, the total prospective

maximum demand on the DVC system was assessed at 282 MW, 459 MW and 555 MW during the next five, ten and fifteen years. While the region covered by the survey can be reasonably served when the project is fully implemented, it may not be possible to reach all the loads during the first phase of development. Accordingly, for the present, only those loads have been taken into account which can be conveniently catered for in the first phase (Fig. 25). The initial power installations, aggregating 294 MW of installed capacity, are made up of 150 MW at Bokaro thermal station, and 144 MW of hydro installations covering Konar (40 MW), Maithon (60 MW), Tilaiya (4 MW) and Panchet Hill (40 MW). The Bokaro station and the Tilaiya dam have been completed, the Maithon and the Panchet Hill stations are likely to be ready by 1955-56 and the Konar station in the following years. The power tariff for the D.V.C. grid is given in Table V.

TABLE V: POWER TARIFF FOR DVC GRID

Demand Charge:
- First 2,000 kVA: 8s. 9½d. per kVA/month
- Next 3,000 kVA: 8s. 0½d. per kVA/month
- Next 5,000 kVA: 7s. 3½d. per kVA/month
- Next 10,000 kVA: 6s. 6½d. per kVA/month
- Over 20,000 kVA: 5s. 9½d. per kVA/month

PLUS

Energy Charge:
- First 200,000 kWh/month: 9/16th of a penny per kWh
- Next 300,000 kWh/month: 17/32nd of a penny per kWh
- Next 500,000 kWh/month: 8·1/16th of a penny per kWh
- Next 1,000,000 kWh/month: 15/32nd of a penny per kWh
- Over 2,000,000 kWh/month: 3·6/8th of a penny per kWh

subject to coal clause, basic rate = 15s. per ton.

Power from the above system will be distributed

TABLE IV: MAITHON AND PANCHET HILL DATA

	Maithon Dam	Panchet Hill Dam
River Basin:		
Drainage area	2,430 sq. miles	4,234 sq. miles
Average annual rainfall	50 in.	48 in.
Maximum flow	250,000 cusecs.	640,000 cusecs.
Average	3,600 cusecs.	7,000 cusecs.
Dam:		
Height (max.)	162 ft.	133 ft.
Length: concrete portion	1,300 ft.	1,175 ft.
earth portion	2,005 ft.	1,800 ft.
earth dykes	7,761 ft.	18,000 ft.
Reservoir:		
Storage (total)	1,104,000 acre ft.	1,214,000 acre ft.
Controlled flood storage	440,000 acre ft.	881,000 acre ft.
Live storage	496,000 acre ft.	185,000 acre ft.
Power Plant:		
Maximum head	154 ft.	120 ft.
Minimum head	85 ft.	67 ft.
Normal head	110 ft.	85 ft.
Installed capacity	40,000 kW	40,000 kW
Benefits:		
Perennial irrigation	270,000 acres	683,850 acres
Total power units	164,000,000 kWh per year	100,000,000 kWh per year

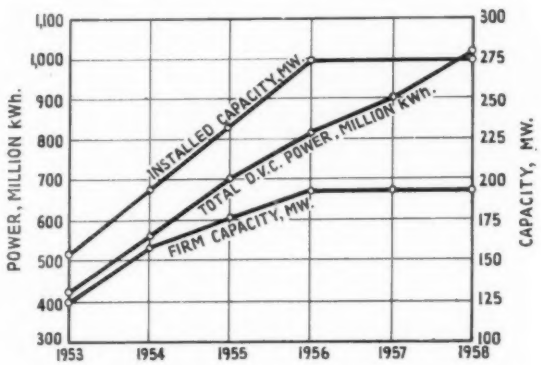


Fig. 25. Growth of capacity and load on the D.V.C. power system

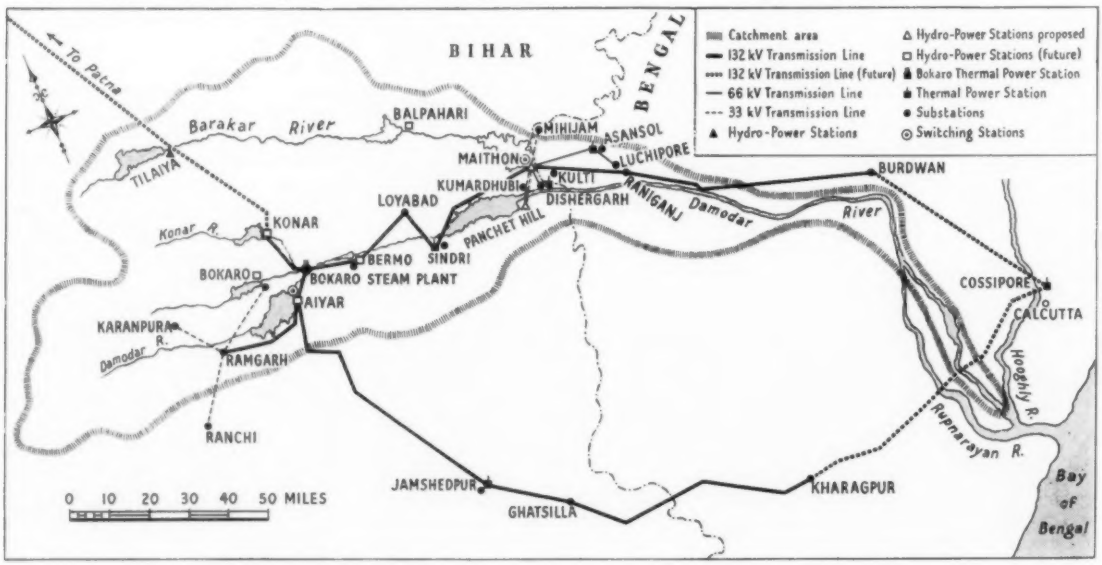


Fig. 26. Map of the D.V.C. generating station and transmission system

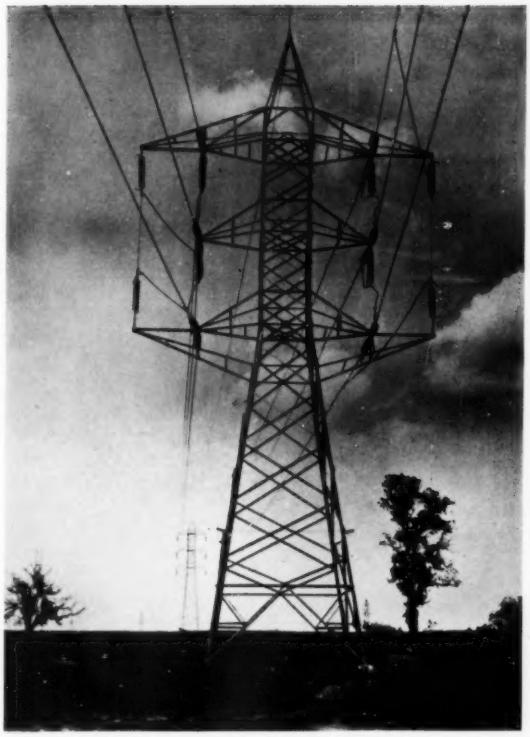


Fig. 27. Typical 132 kV transmission tower

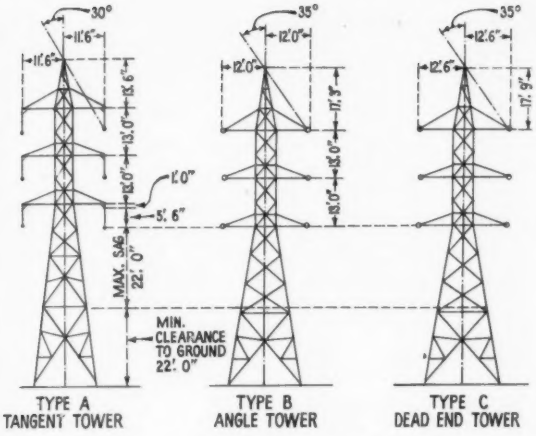


Fig. 28. Types of 132 kV transmission towers

through a transmission network consisting of 375 miles of 132 kV line, 32 miles of 66 kV and 96 miles of 33 kV lines (Fig. 26). This will connect up all the stations and extend from Ramgarh in the west to Burdwan and Kharagpur in the east. The transmission system has been planned to serve the existing industries in the valley in the initial stage, and the design is flexible enough to cater for future expansion. Already an interim distribution system is at work distributing, in advance of the main grid supply, a block of 22,500 kW of firm power from the generating station of the Sindri Fertilizer Factory. Construction of the 132 kV lines and the installation work at the grid is proceeding apace. At the end of January 1953, 132 miles of 132 kV line, about 35 per cent. of the total, had been completed as also all the 66 kV temporary lines and 36 miles of 33 kV lines. The transmission system will make available 1,000 million kWh of energy per annum over an area of 25,000 sq. miles.

A typical 132 kV transmission tower is illustrated in Fig. 27. It is of latticed steel type, suitable for double circuit with one ground wire on top. The overall height of the tower is 90 ft., the area at the base is 13 sq. ft. and that at cross-arm level 5 sq. ft. For normal towers, three equal cross arms are provided which allow a

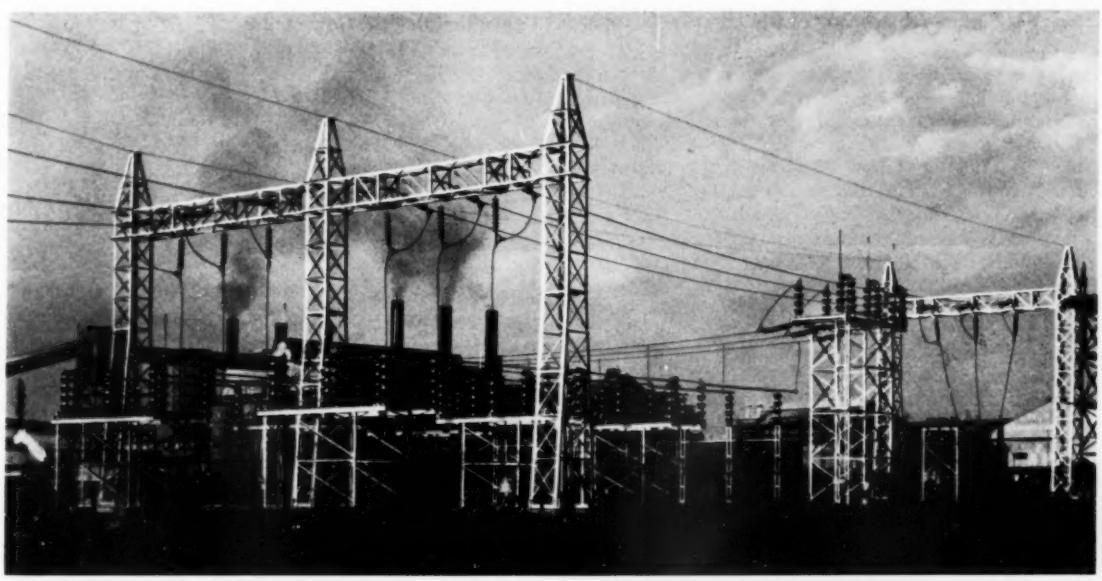


Fig. 29. Sindri substation, with thermal power station in the background

horizontal conductor spacing of 23 ft. For 33 kV distribution locally fabricated H-type structures made of rail are being used. They are about 34 ft. high, vertical distance between cross arms being 4 ft. and the horizontal distance between conductors 8 ft.

Based upon the design load for the ultimate development, the 132 kV line has been provided with 37/·1151 in. steel-cored aluminium conductors (aluminium 30/·1151 in.) equivalent to 0·2 sq. in. copper. Brief particulars of the conductors are: overall diameter 0·806 in.; ultimate strength, 20,000 lb.; maximum design working tension at 35° F., 8,000 lb. at 2·5 factor of safety; maximum sag in still air at 140° F., 22 ft. On the 33 kV distribution line a 7/·1878 in. conductor is used.

The 132 kV line insulators are of standard suspension type 10 in. diameter. These comprise nine discs for a normal suspension string and ten discs for the corresponding strain type. The flashover voltages for a nine-disc unit at 60 cycles is 540 kV dry and 375 kV wet. The corresponding figures for a ten-disc insulator are 590 kV and 415 kV respectively. The 33 kV insulators are of three-shell pin type, 14 in. high, with dry and wet flashover voltages of 145 kV and 100 kV respectively.

To maintain stability in the power system the line circuit breakers are provided with high-speed reclosing, and overload, reactance, impedance, carrier relays. Carrier current relaying is an important feature of the grid. The intercommunication will be through very-high-frequency radio communication. This grid will have a central load-dispatching station at Bokaro to facilitate economic transmission. The circuit breakers used in the grid are of various types, including bulk-oil, minimum-oil and air-blast types.

The following is a list of the manufacturers supplying major equipment for the system: Blaw-Knox Ltd., Great Britain, and Richardson and Crudas, Bombay: 132 kV towers; Aluminium Company of Canada: 132 kV ACSR conductors; Locke Insulators Corporation, U.S.A., and Nippon Gaishi Kaisha: 132 kV line insulators; British Thomson-Houston Co. Ltd., Great Britain: 132 kV bulk-oil circuit breakers; Oerlikon Co., Switzerland: minimum-oil circuit breakers; power transformers from Hackbridge and Hewittic, Ferranti, B.T.H., and English Electric, all from Great Britain.

Acknowledgments

Acknowledgments are due to Mr. A. M. Komora, Chief Engineer, Mr. P. K. Bhattacharjee, Chief Electrical Engineer, Mr. K. M. Chinnappa, Deputy Chief Electrical Engineer, Mr. A. D. Mukherjee, Superintending Engineer at Tilaiya, Mr. M. N. Das, Project Manager at Maithon, Mr. A. N. Lahiri, General Superintendent at Bokaro, and to Mr. C. S. T. Rao Sahib, Superintending Engineer at Konar, who showed the writer round the various works and provided him with the necessary data and information on the projects. Thanks are also due to Mr. K. P. Chatterjee of the Information Office of the DVC who supplied most of the photographs and drawings in these articles.

Moriston Scheme Amendment

The North of Scotland Hydro-Electric Board have published Constructional Scheme No. 23B which amends their Moriston scheme by substituting a diversion of the main trunk road (A.87) between Tomdoun and Cluanie Inn for the original road bridge across Loch Loyne.

The Moriston scheme involves the raising of the surface level of Loch Loyne and the Board originally proposed to carry the trunk road across the loch by means of a viaduct about three-quarters of a mile in length. The new scheme proposes that the trunk road should be diverted along the southern shore of Loch Loyne to join the Invermoriston—Cluanie Inn road (A.887) in Glen Moriston just below the eastern end of Loch Cluanie and that the present road between Loch Loyne and Cluanie Inn should be abandoned. The advantages are that the proposed road would be at a lower level than the present road which is a nominal 9 ft. single-track road with passing places rising to a height of 1,424 ft.; with over five miles at 1,000 ft. it is frequently blocked by snow. The proposed road barely rises above 800 ft. and will be less exposed, less likely to be snowbound and owing to easier gradients and better alignment, less costly to maintain. The Board's proposal will save the Ministry of Transport from having in future to reconstruct about nine miles of the present trunk road between Loch Loyne and Cluanie Inn.

The new road will add about six miles to the route between Tomdoun and Kyle of Lochalsh. The quality and strength of the new road will be much better than the present one. The Hydro-Electric Board are building a new road between Cluanie dam and Cluanie Inn to take the place of the stretch of road which will be flooded by the raising of the water level of Loch Cluanie. This road will be part of the trunk road. Already a substantial part of the Glen Moriston road, about 10 miles from near Torgyle to Ceannacroc, has been reconstructed by the Ministry of Transport, who advanced the work at the Board's request.

Transmission Line Contract. Blaw Knox Limited have been successful in securing a contract to the value of approximately £300,000 for the design and supply of transmission-line towers for Norway. This contract was secured against severe world competition and was placed by Oslo Lysverker for their new 220 kV single-circuit line from Hol to Oslo.

Holman Bros. Limited. As from February 6, 1954, Holman Bros. Limited will be moving their London office from Broad Street House, where they have been for many years, to 44, Brook Street, London, W.1. The telephone number will be Hyde Park 9444 and the telegraphic and cable address "Airdrill, London."

Scott & Wilson, Kirkpatrick & Partners. A new civil engineering and consulting partnership has been formed between Scott & Wilson on the one part and Sir Cyril Kirkpatrick & Partners on the other. Both firms practised as chartered civil engineers and consulting engineers and the new firm will function under the above title. The personnel will consist of Mr. E. C. Measor, A.C.G.I., B.Sc., M.I.C.E., Mr. H. Grace, S.M., M.Sc., M.I.C.E., Mr. R. W. Hawkey, M.A., M.I.C.E., M.I.W.E., and Mr. F. M. Bowen, M.I.C.E., and the address is 47 Victoria Street, Westminster, S.W.1.

Fig. 1. Imperial dam and desilting works

Iowa Fifth Hydraulics Conference

We present a series of specially contributed abstracts of the proceedings of the Fifth Hydraulics Conference held at the Iowa Institute of Hydraulic Research, which was devoted to the general subject of sediment transportation.

PART ONE

AS announced in our November 1953 issue, the Proceedings of the Fifth Hydraulics Conference held at the Iowa Institute of Hydraulic Research have now been published.* The conference was devoted to the general subject of sediment transportation, and the 14 papers were divided into five groups: The Sediment Problem, Movement of Bed Load, Entrainment and Suspension, Scour and Deposition, and Measurement and Analysis.

The following abstracts of the papers presented to the Conference have been prepared specially for this journal by John S. McNown, Associate Director, Iowa Institute of Hydraulic Research, and M. C. Boyer, Associate Professor, Department of Mechanics and Hydraulics.

* The Proceedings are published by The State University of Iowa, Iowa City, Iowa. 302 pp. 139 ff. Price $3.50.

Introductory Remarks, by Hunter Rouse

During the 14 years since the First Hydraulics Conference, perhaps the major accomplishment in the study of sediment transportation has been a healthy broadening of perspective. Problems of scour, entrainment, transport, and deposition are no longer regarded as distinct from one another, nor is each expected to exhibit one simple functional relationship. Still of primary concern are the relation of the suspension function to bed conditions, the perfection of bed and bed-load samplers, and the improvement of size-frequency measurement; more recently appreciated is

the need for understanding the interaction between sediment-laden fresh water and salt water in estuaries. Whether in general analysis or in specific model studies of prototype behaviour, laboratory and field investigations remain equally essential to continued progress.

Twenty Years of Sediment Work on the Colorado River, by C. P. Vetter

With authorisation by the Congress in 1928 of construction of Hoover Dam and the All-American Canal, many unusual problems relating to the regimen of sediment-laden streams were presented to the Bureau of Reclamation. These fall into three categories: the effects of sediment on Lake Mead, the disturbance of the regimen below Hoover Dam, and selection of design criteria for the large diversion works into the All-American Canal at Imperial Dam.

It was realised that storage space amounting to 3·2 million acre feet had to be provided in Lake Mead for storage of an average annual sediment load approximating 200 million tons per year. Practically all the sediment is depositing near the head of the reservoir. Of the two billion tons deposited since 1935, only 42 per cent. has reached the space provided just upstream from the dam. It is estimated that at the present rate of deposition the reservoir will be completely filled within 500 years, but that useful capacity will be seriously impaired long before that time unless the construction of other storage works upstream reduces the rate of transport.

The principal effect on the river regimen below Hoover Dam has been a rapid and pronounced retrogression between Hoover and Parker Dams. Most of the material has been deposited in a swamp above Lake Havasu, and the river has spread out into innumerable sloughs flooding the town of Needles and the Palo Verde Valley. Relief has been obtained by dredging a new channel.

The primary problem in connection with the design of the Imperial diversion dam and the All-American Canal was the desilting works (Fig. 1). This hinged on the extent to which the sediment load in the river would be modified by Hoover and Parker Dams. Extensive studies were made of sediment size and concentration. The desilting works, which utilised mechanical scrapers for removal of the sediment, were studied in model.

Sediment Investigations for Missouri River Projects, by D. C. Bondurant

The history of the Missouri River development is dominated by sediment. The Corps of Engineers has shifted and moulded the stream through use of the sediment which it carries. In accomplishing this earlier work they knew little of the theories of sediment transport, relying instead on practical knowledge. With this background of practical experience plans were laid for a detailed programme of study of sediment

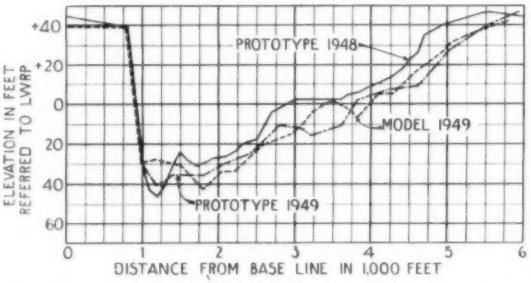


Fig. 2. Model and prototype comparisons for the Concordia-Scrubgrass bend

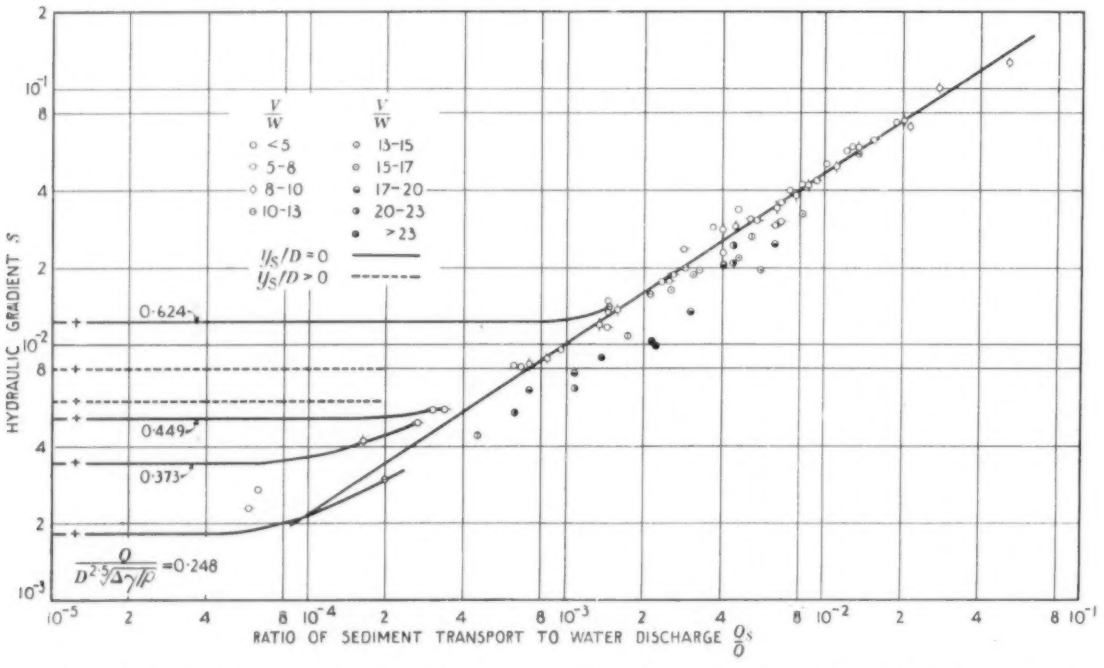


Fig. 3. Relation between hydraulic gradient and ratio of sediment transport to water discharge in pipes

transport. Almost all of the problems to be investigated were found to lie in the realm of the dynamics of sediment movement, principally aggradation in the reservoirs now under construction and degradation downstream from them.

The Corps' sedimentation study is divided into four parts: (1) sampling to obtain more data on sediment loads and characteristics; (2) a review of data previously collected; (3) investigations of existing projects; and (4) evaluation of fundamental transport theories and formulae.

Sediment sampling was carried out during 1929-30 and, beginning again in 1937, numerous stations were established. The review of available data for reservoirs was disappointing as most of the surveys were made to determine loss of storage only. Studies of conditions at existing projects are more satisfactory. Studies of degradation below Fort Peck Reservoir have provided information on natural barriers to bed scouring such as layers of shale and gravel deposits. Investigation of the fundamental transport theories are being carried out by collection of necessary field data for a 10-mile reach of the river near Omaha. Observed results verify analytical results for velocity distribution and sediment concentration. The Corps has also arranged with education institutions for laboratory studies of fall-velocity and transportation formulae.

Application of Hydraulic Studies Involving Movable Beds, by Ernest B. Lipscomb

Much of the work of the Corps of Engineers in the development of navigable waterways involves the control of sediment in alluvial streams, so that the operation of natural channels will not be impaired. Sedimentation problems investigated at the Waterways Experiment Station of the Corps can be divided into two groups: those involving the movement of bed load, and those involving the deposition of suspended sediments.

In model studies for the solution of such problems, careful consideration must be given to the selection of model scale and of bed material, the latter being difficult because scaled bed material would be too fine to use. Distortion both of the linear scale and of the time scale is often necessary, so that model verification is required.

A recent study has been made of proposed channel changes in the Mississippi River in the vicinity of Memphis, Tennessee, at which point the possibilities of seriously endangering a reveted bank of the river, of causing dangerous shoaling, and of increasing the heights of floods were to be assessed. In a distorted model of a 23-mile stretch, crushed coal was used for the bed material and the banks were moulded of concrete. The model was first painstakingly verified for known conditions and then used successfully to test and to modify the proposed plan of river control.

A second model study was for the purpose of developing a technique for predicting changes both in the bed and channel along the banks of an alluvial river. A wide variety of granular materials and binding agents was tested, and comparisons were made between model and prototype for the Concordia-Scrubgrass reach of the Mississippi River as shown in Fig. 2. This type of model is expected to be extremely valuable for studies of channel stabilisation.

A developmental research investigation has also been carried out at the station in order to determine the effects of bed shape, discharge, and initial angle of attack on the characteristics of the channel cross section and meander pattern.

The Transportation of Sand in Pipes, by J. P. Craven and H. H. Ambrose

Among the problems posed by the movement of granular material by a flowing fluid is the control of sediment entering storm drains. In a project supported by the Iowa State Highway Commission and the Bureau of Public Roads, this problem was investigated at the Iowa Institute of Hydraulic Research for conduits flowing both under pressure and with a free surface, the solid material being moved only as bed load. From a series of experiments with various uniform sands, empirical relationships were sought for head loss, transport, and deposition.

Tests were made in 6 in. and 1·5 in. Lucite pipes, and sands with mean diameters of 0·1, 0·25, 0·6 and 1·6 mm. were used. Three cases were considered: (1) flow with the sand on the point of depositing on the bottom; (2) full-pipe flow with some inert sand on the pipe bottom; and (3) free-surface flow with deposited sand. A limiting region was found for which the head loss was effectively independent of the sediment transport. Results were obtained for a wide range of the variables and systematic curves were prepared for the different cases, various dimensionless ratios being utilised in the presentation of the data. The relationship between the hydraulic gradient and the ratio of transport to water discharge is shown in Fig. 3. Design criteria were obtained to aid in the avoidance of deposition, the prediction of the effect on head loss of the material transported, and the calculation of the transport for various values of the discharge, pipe size, and particle size.

Sand Transport by Littoral Currents, by J. W. Johnson

Sandy beaches continually change their configuration because of daily, seasonal, and annual changes in the intensity and direction of attack by sea waves. The transport of sand is most pronounced shoreward from the point of breaking. From an extensive bibliography the present state of knowledge concerning the combined characteristics of beaches and waves can be assessed.

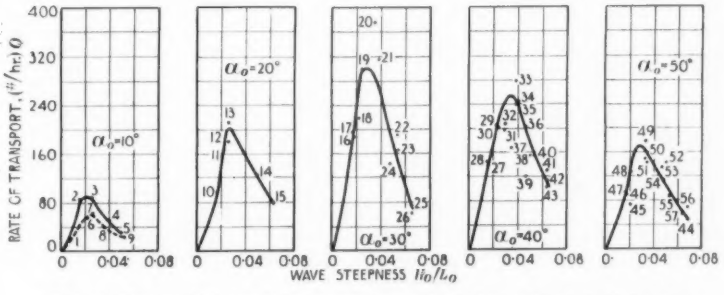


Fig. 4. Rate of littoral transport as a function of wave steepness

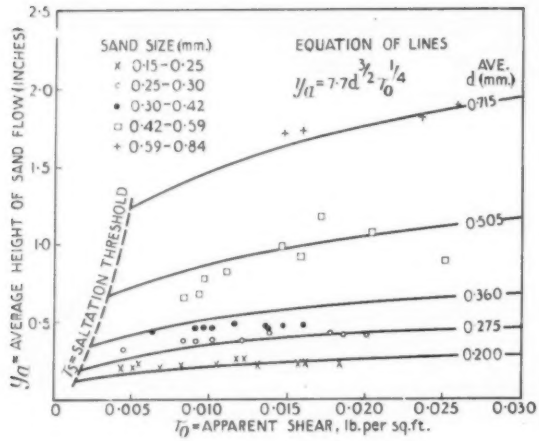


Fig. 5. Average heights of saltation

Although waves approaching a shoreline at an angle tend to become parallel to the coast, they break at a small angle thereto and induce a littoral (alongshore) current which moves sediment both in suspension and along the bottom. From model studies at the University of California the rate of littoral transport is presented as a function of wave steepness (wave height divided by wave length) for various angles of wave approach (see Fig. 4). A maximum rate of transport is found for a wave steepness of 0·025; steeper and less steep waves correspond to distinct classes described as "storm" waves and "ordinary" waves.

Field studies conducted at Santa Barbara, California, provide information on the average values of transport rate, wave power, and average wave steepness. The wave angles were obtained indirectly by the method of hindcasting. From the available data, the average and maximum rates of sand transport were estimated. It is not possible, however, to formulate a general relationship. Both model studies and harbour surveys are needed to determine the effects of variability of the waves and tides.

Wind-Tunnel Studies of the Movement of Sedimentary Material, by A. W. Zingg

Knowledge of the characteristics of sand and soil movement by wind is essential to the prevention of wind erosion. In order to add to the rather meagre knowledge on this topic, a portable bottomless air tunnel for field use was designed and tested extensively in the laboratory of the Soil Conservation Service at Kansas State College. The tunnel duct was 3 ft. square and 56 ft. long. Air movement was produced by a petrol engine and a ventilating fan. Sands of nearly constant diameters were used, the mean sizes varying from 0·2 to 0·7 mm.

Part of the sand placed on the bed of the tunnel was supported in a tray which was floated to make possible the direct measurement of shearing stress. The distribution of the air velocity above the beds was measured first, the sand having been fixed or stabilised by wetting. The effective roughness of the bed, the shearing stress, and the characteristics of the logarithmic velocity distribution were determined. For dry beds the initiation of movement and the distribution of sediment moving in suspension were then observed. The average heights of saltation are shown in Fig. 5.

Although the laboratory condition was artificial because of the limited extent of the tunnel and the artificial generation of turbulence, the measurements were illuminating. Observations of the shear and of the velocity distribution provided useful correlations with the boundary roughness. A technique for determining a definable threshold velocity or shear for the commencement of saltation was developed, and equations were obtained for the distribution of the drifting sand.

Some Effects of Suspended Sediment on Flow Characteristics, by V. A. Vanoni

In flows transporting sediment, the configuration of the channel bottom and possible internal changes will affect the resistance coefficient. In order to analyse these effects, experiments were conducted at the California Institute of Technology in which the hydraulic slope and the hydraulic radius were held constant and the amount of sediment available for the flow to transport was varied. A flume 60 ft. long and 33 in. wide having an artificially roughened bottom was used. The distribution of sediment concentration was determined by sampling.

The resistance coefficient was found generally to decrease with increasing concentration, even in some cases in which dunes formed. From comparisons of the observed results and the trends based on the assumed logarithmic velocity distribution, the value of the von Kármán constant was also found to diminish with increasing concentration as shown in Fig. 6, values as low as 0·2 having been found.

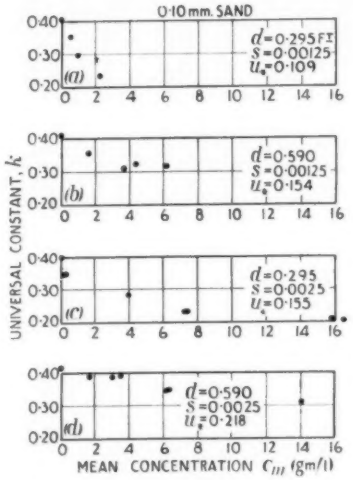


Fig. 6. Variation of von Kármán constant with sand concentration in a flume 33 in. wide

It was concluded from the results of the experiment that the suspended sediment damps the turbulence of the flow so that the exchange coefficients of both momentum and sediment are reduced as the concentration increases. The friction factor is also reduced as the transfer coefficients reduce, but tends to increase with the formation of dunes. The accepted transport theory for suspended sediment is useful but inadequate to account for these internal effects.

(To be continued)

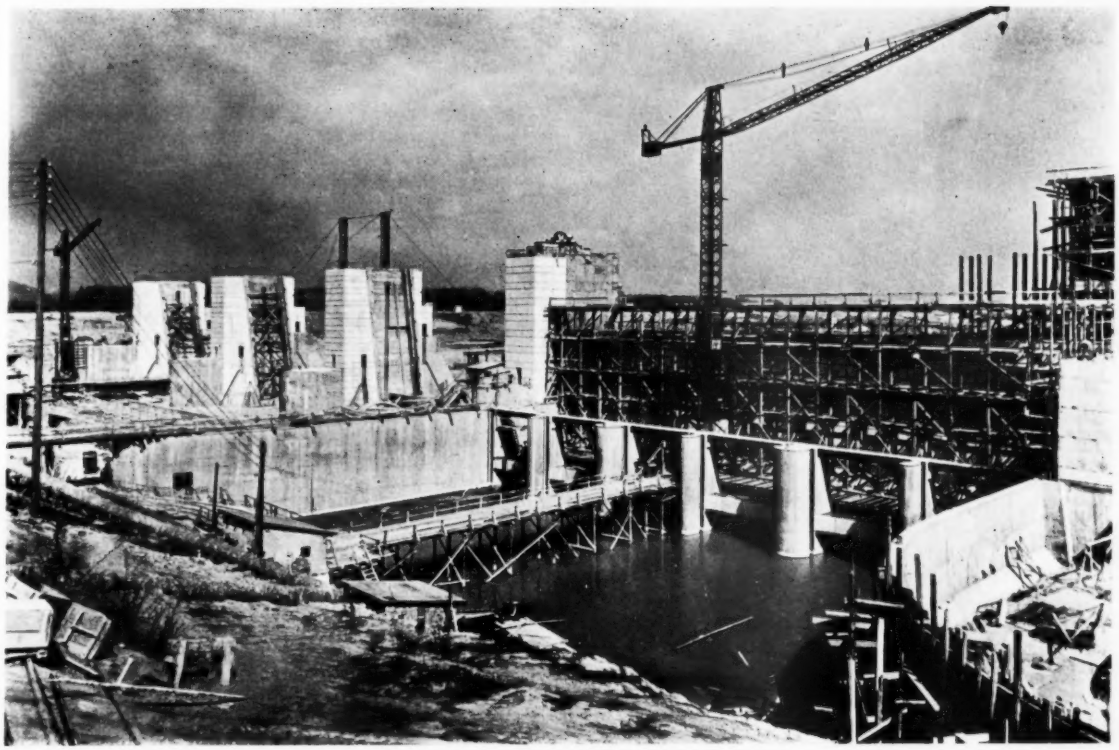


Fig. 1. Tiszalok dam under construction

Danube Valley Water-Power Plans

A summary, by Gordon Stewart, based on a correlation of reports in the Eastern European press.

EXTENSIVE plans now exist for the control of the Danube valley rivers, according to reports in the Eastern European newspapers. According to the Czechoslovak press, the Danube is to be connected to the Elbe, the Oder and the Vistula by canal. Hungarian sources indicate that four barrages will be constructed on the Danube where it flows through Hungarian territory, and that extensive work is already being carried out on the Tisza, a turbulent tributary of the Danube, which flows through Hungarian territory from north to south. Rumania has plans for a canal to join Bucharest to the Danube, and work is already advanced in cutting a canal from the Danube to the Black Sea at Constanta, thus saving vessels over 100 miles of river journey and avoiding the dangerous passage through the Danube Delta.

Two interesting factors emerge from these plans. The first is that they are not only concerned with transport, but also electric power and irrigation. All canals and locks are designed to take 1,000-ton barges, enabling heavy goods, and particularly coal and iron ore, to travel by water. This is of particular importance, as many of the Danube countries now obtain large quantities of iron ore from the Soviet Union, and coal either from the Soviet Union or from Poland. The Polish canal system is to be linked with the Ukraine canals, with the result that it will be theoretically possible in some years' time to travel from Moscow to Moscow via the Vistula, the Danube and the Black Sea. Another important factor in this situation is that extensive advice and assistance seems to have been obtained from Soviet engineers. Considerable quantities of Soviet equipment is already on the sites, including large walking dragline excavators. One of these is known to be in use in Hungary, and another at the Danube—Black Sea canal.

The Czechoslovak scheme consists of building a canal from Bratislava right across Czechoslovakia to the Oder at Kozli. A junction would connect with the Elbe at Kolin. The Polish canal plan covers the construction of a canal connecting the Vistula with the Oder. The project has already been under investigation for several years, according to Prague press reports, and the canal will be 187 miles long, 132 ft. wide and 14 ft. deep, and will include 12 locks.

In Hungary, according to a report in *Magyar*

Fig. 2. A Russian-built excavator at work on the Danube-Black Sea canal

Technika last June, an extensive survey has been carried out of water-power resources. It is estimated that the 95 per cent. theoretical water-power potential is 4,100 million kWh annually, and the 50 per cent. theoretical water-power potential is 7,200 million kWh. It is considered that at 50 per cent. flow, 2,500 million kWh would be technically available, and that 1,500 million kWh of energy is the economic utilisation. At present only a tiny percentage of water flow is used for power production. Hungary's interest in water power is shown by the fact that in recent years a Water-Power Planning Office has been set up, under Dr. Emil Mosonyi, a member of the Hungarian Academy of Sciences. It is this organisation that carried out the water-power survey.

The first scheme on which the Hungarians have embarked is the control of the Tisza. This consists of three barrages, the first of which will be completed by the spring of 1954. It is situated at Tiszalok, just below the confluence of the Tisza and the Bodrog. By raising the level of the Tisza by 27 ft., it is made permanently navigable for 50 miles upstream, and the Bodrog for 30 miles, as far as the frontier. In addition to the barrage, a 60-mile long gravitation canal is being dug straight south across the arid Hortobagy plain to the Berettyo river, which flows back into the Tisza. A further irrigation canal and several reservoirs will also be constructed on the Plain. As well as providing for transport in 1,000-ton barges through a length of 431 miles, the canal and its subsidiaries will enable 250,000 acres to be irrigated.

The barrage consists of three movable sluices each 120 ft. wide. The lock, capable of taking barges with a displacement of 1,200 tons, is 280 ft. long and 54 ft. wide. The power station houses three Kaplan-type turbines with an intake of 95 cu. m. per second, with an average annual energy production of 55 million kilowatt hours. The power-station machinery will be manufactured in Hungary, whose engineers have considerable experience of this type of work. After exploratory investigations had been carried out, work on the site began in 1950. Construction is well advanced, the turbines were in course of assembly during last summer, and electric power is planned

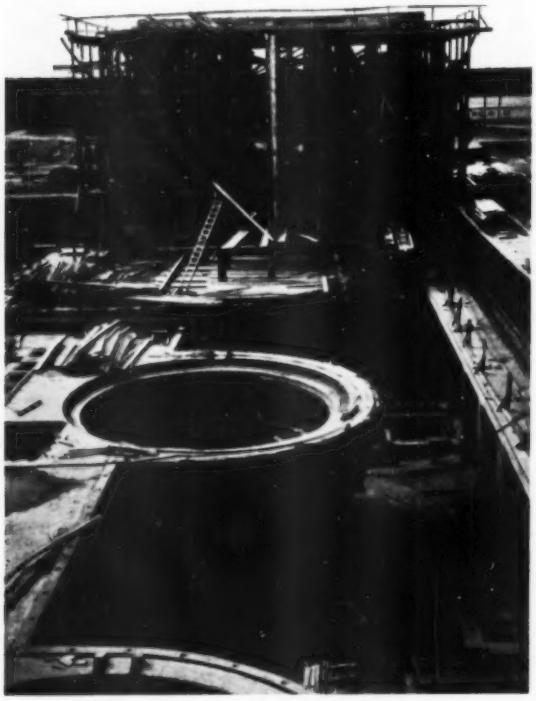


Fig. 3. Foundations for the Kaplan turbines in the Tiszalok station

Fig. 4. View of the construction site at Tiszalok, looking downstream

to be produced during the spring of 1954.

The Tisza, notoriously dangerous and unreliable for navigation, and given to serious spring floods, is to be brought under complete control by the construction of the second and third of the three barrages mentioned earlier. According to preliminary research, these will be at Szeged, near the southern Hungarian frontier, and at Tiszabura, midway between Tiszalok and Szeged. The construction of a canal between the Danube and the Tisza is understood to be under consideration. Thus, the industrial areas around Miskolc would be connected with Budapest and the Danube river traffic, a matter of some economic importance.

The main source of hydro-electric power in Hungary, of course, is the Danube. Plans are now under investigation for controlling the whole of this river during its passage through Hungary. It is estimated that, on a basis of a 50 per cent. water flow, an average of 4,951 million kilowatt hours could be produced annually.

The provisional scheme for the Danube is understood to be based on a total fall of the river during its passage through Hungary of 66 ft. This would be harnessed by four barrages. The most obvious situation for two are at Visegrad, in northern Hungary, where the river passes between hills, and at Mohacs, near the Yugoslav border. The other two may be situated first where the Danube enters Hungarian territory from Czechoslovakia, and secondly at Adony, south of Budapest and just north of the new million-ton iron and steel works at Sztalinvaros.

Fig. 5. Estimating the flow of the Danube by lighted floats at a dam site at Visegrad

The main scheme in Rumania is a canal running from the Danube near Cernavoda into the Black Sea near Constanta, and passing through the Dobrudja region. The canal will be about 30 miles long and will cut the passage up the Danube by 144 miles.

Work started in 1949 and includes the construction of a new port on the Black Sea. It is also closely linked with land reclamation in the Dobrudja area, previously malarial and unfertile.

The Chartered Mechanical Engineer

The Institution of Mechanical Engineers have decided to start an entirely new publication, under the above title, to supersede their present *Journal*. This change is in keeping with the times and represents a greatly improved service to the membership, which now exceeds 40,000. The new journal, in addition to keeping members acquainted with the various activities of the Institution, will also contain the text of lectures and addresses, together with adequate summaries of all the papers accepted for publication in the *Proceedings*. These summaries will appear from four to eight weeks in advance of the meetings at which the papers will be presented and, of course, a member who is specially interested in any particular paper will still be able to obtain an advance copy as hitherto. The new journal will be published monthly, the two holiday months, July and August, excepted, so that ten numbers will appear per annum.

Blaw Knox Scraper. Publication BK187 issued by Blaw Knox Limited illustrates and gives technical particulars of the BK-20 MK.11 Scraper, which is designed for operation with Class II Group 3 and Class III (101-175 h.p.) tractors. Drawings and a full specification are included.

Rubber Paints and Latex-Cement Compositions. A brochure issued by The British Rubber Development Board gives particulars and emphasises the practical advantages of paints incorporating natural rubber derivatives. Such paints are claimed to have distinctive characteristics of good flow, to be nonsettling and to afford superior protective properties. A further brochure discusses the use of natural rubber latex-cement compositions in buildings, in which it can be applied as floors, underlays, for fixing glass, and for lining water tanks and conduits.

General Electric Scrapbook. The International General Electric Company of New York have published a Scrapbook which traces the history of the firm's 75 years of growth, beginning with Edison's invention of the incandescent light bulb. A host of contemporary photographs and drawings are reproduced and the text gives an interesting commentary on the various development stages of the electrical industry and on the personalities associated with them. In considering modern electrical machines with their odd looking predecessors of the 1880's it may well be wondered what the next 75 years is to bring forth, but strangely enough, Edison's original light bulb is not so very dissimilar to its present-day counterpart.

Exports of Pressure Vessels to Canada. The British Standards Institution has set up a section to deal with the approval in the United Kingdom of air receivers, boilers and pressure vessels intended for export to Canada. Initially the B.S.I. and the Chief of the Boiler Inspection Department of Quebec drew up arrangements to cover the necessary service, and these have now been extended by agreement with the Canadian Standards Association's Committee on Canadian Boiler Regulations to all Canadian Provinces, whose chief inspectors have agreed to accept equipment manufactured in the United Kingdom provided that: (1) the necessary registration with Canada has been effected; (2) the equipment has been constructed in accordance with the relevant Canadian specifications; and (3) the necessary inspection during and after construction has been carried out by an accepted Inspection Agency.

84 in. Rotovalves for Afghanistan

THREE 84 in. diameter Rotovalves, stated to be the largest of this type so far constructed, are being built by the S. Morgan Smith Company for the Afghan Government for Kajakai dam on the Helmland River about 125 km. north-west of Kandahar. The dam is a composite earth and rockfill structure rising to 94 m. above foundation and 273 m. long at the crest. Discharge will be through two tunnels, each 10·4 m. in equivalent diameter, below the left abutment. The tunnel nearer the river bed is intended to supply a future power plant and is not yet in use; the outer tunnel, about 710 m. long, is for irrigation and is now in service.

It is in this tunnel that the three valves are being installed. Each valve will be located at the outlet of an 84 in. steel pipe extending 150 m. into the tunnel, the upstream ends of the three pipes being encased in a concrete plug which completely fills the space between the pipes and the tunnel walls. The head on the valves will range from 79 to 246 ft., and at the maximum head the discharge will be 2,750 cusecs.

The rotating-cone type of valve was selected for this service because (1) it presents an unobstructed bore at full opening, (2) it requires relatively little power to operate, (3) it can be opened and closed under full head, (4) there is no seat contact during rotation, (5) the cone can be seated in any position. The distinguishing feature of this type of valve is the unseating motion by slightly withdrawing the plug before rotation. This virtually eliminates seat wear and removes seat friction from the forces to be overcome by the turning effort. Two oil-operated servomotors are provided, one for lifting and the other for turning, and they are so interlocked that the turning motion cannot be applied unless the cone is unseated.

Seeing that the design pressure, 115 lb. per sq. in., is relatively low, it was decided to fabricate the valves entirely from steel plate and avoid the use of steel castings. The only formed surfaces are the upper and lower dished heads, which are standard steel-mill products. Structural-quality carbon-steel plate has been used throughout, the dished ends being constructed of 2 in., the valve bodies and cone walls of $1\frac{1}{2}$ in., and the waterways and stiffening members of 1 in. plate. Electric welding was employed throughout, the assemblies being carried in manipulators to permit downhand welding. A careful welding procedure was followed, and all parts were thermally stress relieved before machining.

Monel-metal seatings are fitted to both body and cone, and the contact faces were ground to a perfect fit with an abrasive compound by a motor rig which gave a to-and-fro rotating movement to the cone.

After shop assembly each valve was subjected to a pressure test of 125 lb. per sq. in. With bulkheads at both waterways the cones were found to rotate freely. With the downstream bulkheads removed and the cone seated in the closed position pressure was applied to the upstream side. A leakage of 5 quarts per minute was noted, confined almost entirely to the flanged body joints on the centreline of the waterways, and it was considered that the use of the proper gasket material in the final assembly on site would virtually eliminate this leakage.

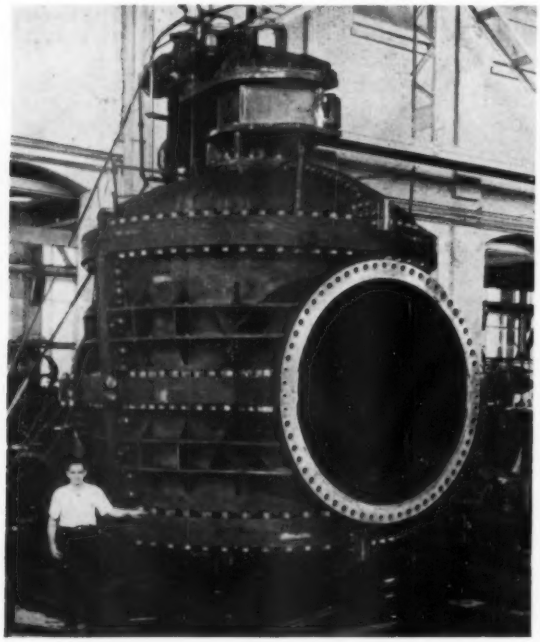


Fig. 1. Morgan Smith 84 in. Rotovalve in the maker's works

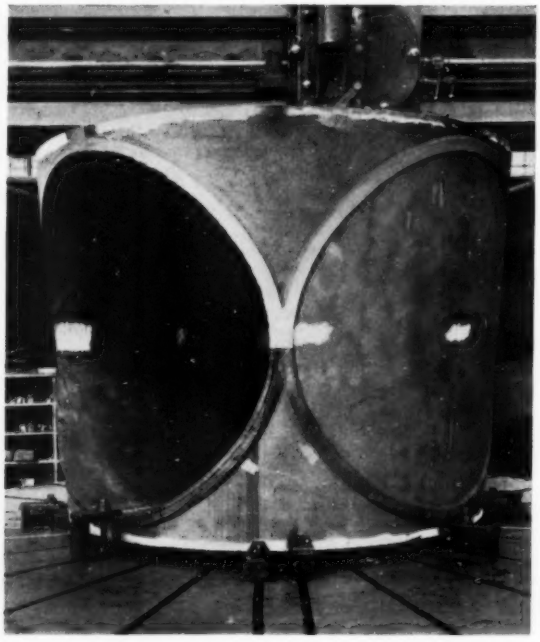
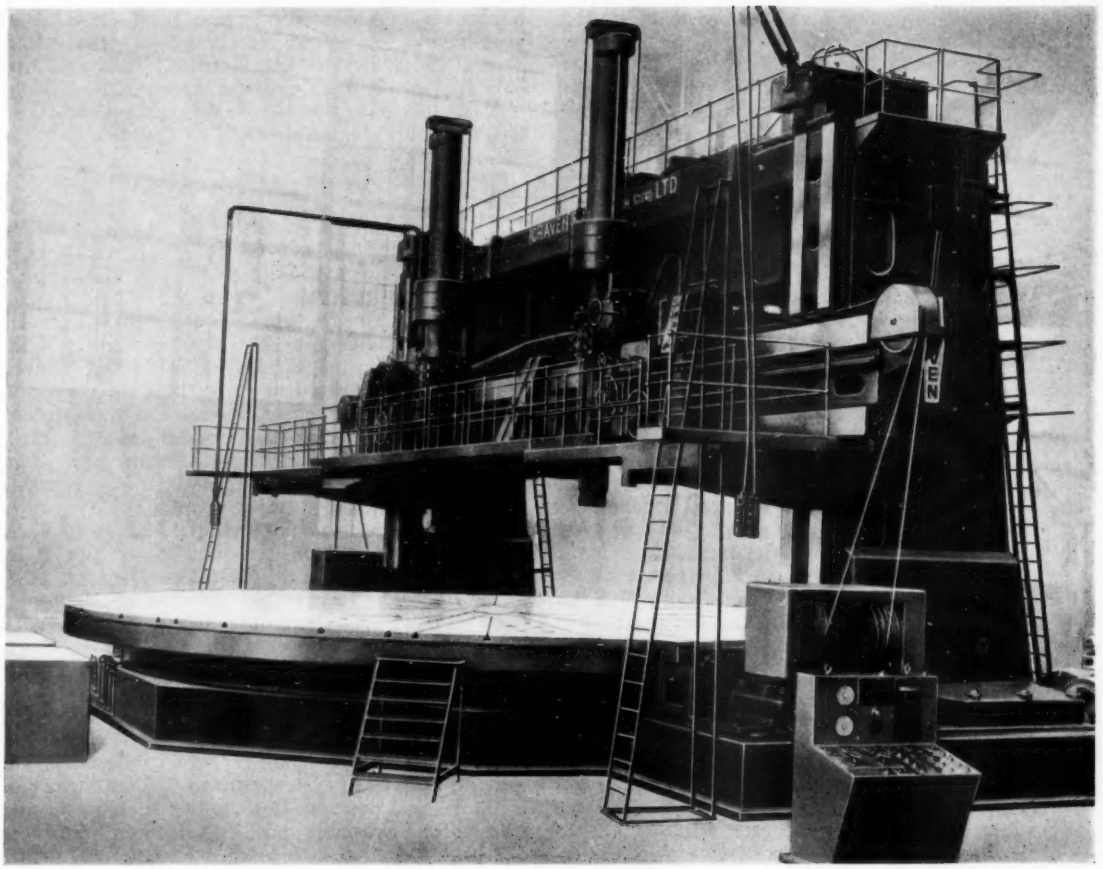


Fig. 2. The fabricated cone for one of the Rotovalves on the boring mill



Craven 42 ft. Vertical Boring and Turning Mill

A 42 ft. vertical boring and turning mill was recently completed by Craven Brothers (Manchester) Ltd. to the order of the English Electric Co. Ltd. for installation in the new Toronto works of their Canadian associates, John Inglis & Co. Ltd., primarily for use in the manufacture of large water turbines. It is of the fixed double-column type with a 41 ft. diameter table, and is capable of swinging work up to 42 ft. 6 in. diameter between the uprights, and of accommodating 13 ft. 4 in. in height beneath the tool boxes. This huge machine, weighing approximately 650 tons and occupying a floor space of 63 ft. by 58 ft. 6 in., has an overall height of approximately 40 ft. It is capable of handling workpieces up to 140 tons weight, and was thoroughly tested with a 100 ton load before leaving the Craven workshops.

As would be expected in a machine of this size, several difficult machining and assembly problems had to be faced in the initial design stages. These involved the subdivision of major components into sections within the capacity of the available manufacturing plant. Methods had to be devised whereby certain important outsize machining operations could be carried out in position after partial or complete machine assembly, and special foundations were necessary to accommodate the machine during construction. The machine embodies independent electric motor drive to the table, to each ram saddle, to the cross-slide elevating and locking motions, and to the main lubrication systems and speed-change mechanism, while interlocked electrical equipment reduces as far as possible the risk of damage due to mishap. Other features include an oscillating planing motion drive to the worktable and dial indication of table-track and spindle-bearing temperatures.

The machine bed is constructed in eight sections, jointed, keyed, and bolted together to form a single rigid unit, the assembly being supported on its foundations by numerous screw-operated levelling wedges, which are accessible for adjustment from trenches formed in the foundations.

The worktable comprises a central circular portion, 14 ft. diameter, to which twelve separate seg-

mental pieces are jointed and keyed to make up the full table diameter. The vertical load of the table and workpiece is supported by three concentric flat tracks mounted on top of the bed. The inner track supports the centre table member, while the intermediate and outer tracks support the outer table sections. All tracks are constructed in sections and are fitted with bronze bearing pads, while for central location the table has a 4 ft. 6 in. diameter spindle of conical form which rotates in bronze bearings.

Lubrication of so large a rotating unit, itself weighing in all approximately 170 tons and supporting a workpiece in the neighbourhood of a further 120 tons, is of paramount importance. The spindle runs in an oil bath formed by its bearing housing, in addition to which there is a pressure oil feed direct to the bearing faces. Duplicate sets of oil pumps, driven by two separate 5 h.p. motors, supply the table lubrication system, one set generally acting as standby.

The main drive to the table is by two 150 h.p. variable-speed motors, with a 3 to 1 speed range, operated from a single 410 h.p. Ward-Leonard-type motor-generator set. The two motors are arranged electrically so that they equally share the total load. Each motor is directly coupled to a separate three-speed gearbox at the rear of the bed, from which the drive is transmitted by a power-operated multi-plate friction clutch to bevel reduction gears inside the bed. The driven shaft from the bevels passes down to further large reduction gears, of spur type, housed beneath the bed and thence to a second vertical shaft upon the top of which is mounted a final driving pinion. Thus there is a perfectly balanced drive by two separate pinions meshing, at points approximately 90° apart, with a single 26 ft. 5 in. diameter 13 in. face external-spur table gear ring.

Motor-driven oil pump units provide cascade lubrication for the two driving pinions, and automatic oil circulation is provided also for the reduction gearing in the bed. The whole of the table pinion drives can be dismantled and reassembled from below the bed, when the machine is in position on its foundations, without removing the table or its bearing tracks.

In conjunction with the three-speed gearboxes, the variable-speed motors give a stepless table speed range from 0·15 to 3·5 r.p.m. All gear changing in the two boxes is carried out electrically, and is effected by switches on the main control desk. Further push-button switches on the desk control a separate 1½ h.p. motor which engages or disengages the two main drive friction clutches simultaneously. By this means the gears may be relieved of all load and "inched" round to facilitate gear changing. Electrical synchronising ensures that the main motors cannot be started for continuous rotation until the two gearboxes are set to the same ratio and until the clutches have been re-engaged.

In addition to the normal continuous rotation of the table, the electrical equipment is designed also for automatic partial rotation and reversal for the purpose of machining intermittent or local surfaces in the manner of a planing machine. For this operation planer-type control is provided, and a two-way switch selects either normal rotation or planing motion. Planer-type cutting stroke is available in the normal table direction only, at rates varying from 0·15 to 1·2 r.p.m., the arc of cutting ranging from a minimum of about 5 ft. measured on the edge of the table to nearly a complete revolution. Craven planer-type feed control provides intermittent feeds, from 0·006 to 1·0 in. per stroke in the horizontal direction and from 0·003 to 0·5 in. per stroke in the vertical direction, which are available on the right-hand saddle only for use when planing.

Each of the two uprights weighs approximately 27 tons. Together they form a rigid support for the cross-slide and are connected together at the top by a deep box-section cast-iron tie beam. The uprights have wide vertical slideways both on their front and inner side facings to locate the cross-slide.

The cross-slide has an overall length of 56 ft., weighs approximately 72 tons, and is built in four cast-iron sections bolted and keyed together. It is arranged to fit both on the front and inner faces of the uprights, although in actual practice a slight float is allowed in the latter instance. Electrically operated locking mechanism, driven by two 3 h.p. motors, locks the cross-slide to the uprights when in the required working position.

The whole cross-slide unit is raised or lowered at a speed of about 12 in. per minute by four 5 in. diameter 1 in. pitch vertical screws, arranged adjacent to the inner faces of the uprights, and long nuts built into the cross-slide. The screws are driven by four worm reduction gears, through the necessary shafting, from a 40 h.p. d.c. motor centrally situated on the tie beam.

Two saddles are mounted on the cross-slide, each having a hexagon ram fitted with a three-position tool box. Power-operated swivel slides allow the rams to be set at any angle up to 30° on either side of the vertical position. Each saddle is complete with its own 5 h.p. variable-speed traverse motor and feed gearbox. A 3 to 1 motor speed range is augmented by a series of six gear changes to provide a nominal feed range in both the horizontal and vertical directions of from 0·013 to 0·75 in. per revolution of the table. Both motor speed variation and mechanical gear change can be made without stopping the machine. The tool rams have 8 ft. 6 in. vertical travel in their swivel slides, while the speed of horizontal quick traverse of the saddle is 8 ft. per minute, and that of the ram vertically 4 ft. per minute.

Twenty-eight separate motors and generators are employed for operation and control of this huge machine tool, and the electrical system includes special control circuits and interlocking devices designed to ensure the maximum degree of safety and convenience.

Operational switches and other features are embodied in a main desk-type control board adjacent to the right-hand upright. Smaller desk-type push-button pedestals on each saddle operate the main motor and the saddle motors for turning, boring, planing and quick power traverse, and two further pushbutton stations of the pendent type, suspended from swivelling arms, duplicate the main motor controls and operate the feed motors for turning, boring and quick traverse only.

All motors and generators were supplied by The English Electric Co. Ltd to specification, while the electrical control equipment was built mainly by Brookhirst Switchgear Ltd. in close collaboration with Craven Brothers, who were responsible for the general design of the whole electrical scheme.

Abstracts from the World Technical Press

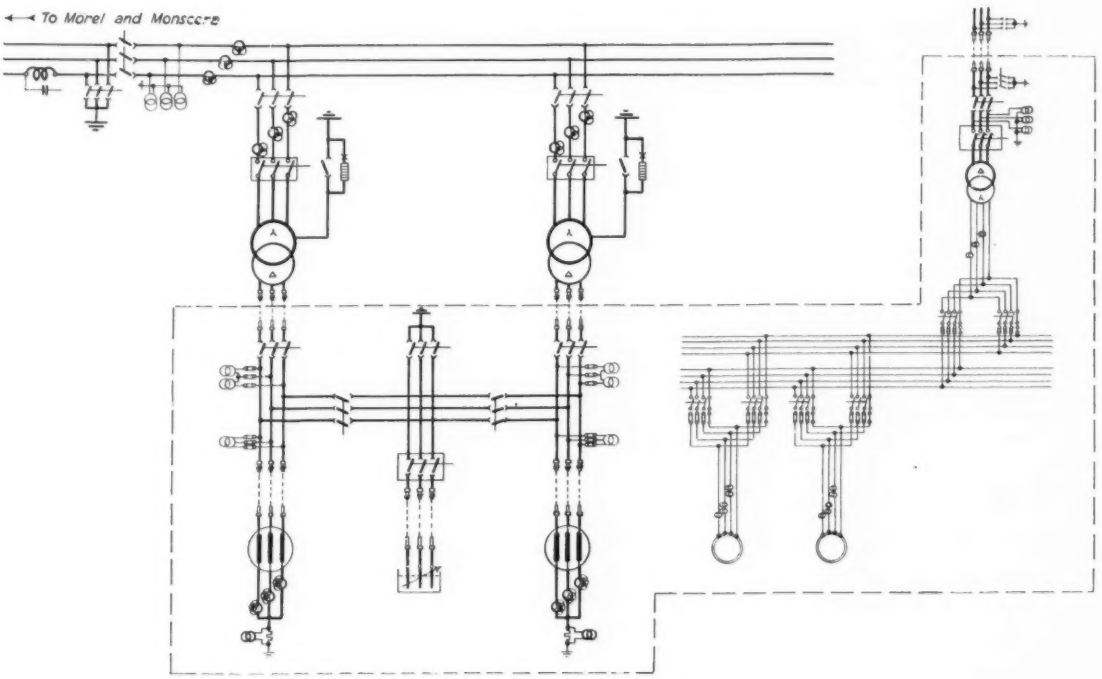
Gondo Power Station

A detailed description is given of the mechanical and electric equipment of this plant, which constitutes the first stage of the Simplon Development. The prime movers of the two 20,000 kVA generating sets are single Pelton wheels actuated by a single jet—a solution which was adopted because the single jet permits a straight assembly of the control valve and nozzle, thus reducing load losses, as well as wear and tear of the nozzle and buckets, to a minimum. As is common practice nowadays, the valves and nozzles are situated underneath the floor of the machine hall in such a way as to ensure easy access while, at the same time, clearing the operating floor of piping and valve gear.

The three motions of the travelling crane can be operated either from the driver's cab or by means of a set of push-buttons fitted on to the end of a cable, from the floor, both systems interlocking.

Each alternator is coupled to the corresponding transformer so as to form a single block; the alternators are both air and water cooled, and their protection against fire is ensured by a CO^2 system. No special protection is provided for the transformers, since they are erected in niches and adequately isolated from other equipment; besides, the outlet pipe of the transformer tanks empties into an outdoor underground sump in front of the building.

As soon as ancillary voltage is available to both the oil-pumps of the governor and main control valves, all operations connected with the starting and supervision of the plant can be effected from the control room; some of the measuring apparatus and control gear are doubled, however, to enable emergency control from the machine hall. A comprehensive system of protective gear, supported by an extensive network of signals, enables the control staff to cope with all contingencies occurring in actual practice. (Contributed by Société Ofinco S.A., Geneva, *Bulletin de l'Association Suisse des Electriciens*, Vol. 44, No. 22, 31.10.1953, p. 952, 8 pp., 12 ff.)



Circuit diagram of Gondo plant

Note: The civil engineering works of the Gondo plant have been reviewed in our issue of August 1952, p. 318.

Hydro-electric Development and Local Interests

Various problems confronting the promoters of new hydro-electric undertakings in Switzerland are examined and briefly discussed. It is obvious that, in a country which draws a substantial part of its national income from its tourist industry, new projects often meet with strong opposition from various quarters which, not infrequently, disregard the advantages they could draw from them.

New schemes involving the erection of storage reservoirs in mountainous regions can hardly come into being without altering the neighbouring landscape; local interests are more or less affected and the opposition to such schemes is perfectly natural. In the case of run-of-river plants, this opposition can be satisfied by adapting the structures to the landscape or,

in some instances such as the Drava plants on the Austro-Yugoslav border, by building the structures under water. All-round satisfactory solutions have frequently been arrived at by the co-operation of the technologists with the communities interested.

On the other hand, as shown by the Oberhasli scheme, the construction of power plants in mountainous districts had proved so beneficial to the population as to sweep away every objection. Small communities to which access was extremely difficult now enjoy the benefit of good roads, new schools, electric lighting and modern sanitary installations, not to mention the taxes and rates paid by the power enterprises.

The possibility of a fruitful co-operation between capital and technique on the one hand, and local interests, tourist organisations and nature lovers on the other, is therefore clearly disclosed. (J. Bächtold, *Tecnica*, Vol. 2, No. 9, 24.4.1953, p. 1, 3 pp., 11 ff.)

Dam Construction Plants for High Altitudes

The production of hydro-electric energy in mountainous countries has led to the setting up of large-scale construction plants at altitudes which, in some Swiss instances, reach 2,600 metres above sea-level. These plants must satisfy exceedingly severe conditions proceeding from the size of the works, from the short constructional periods available and, more especially, from topographical and climatic conditions. Compared with installations in flat, open country, those in mountainous regions require an absolutely flawless organisation and leave no room for easy or makeshift solutions.

The provision of transport facilities is of the utmost importance. This means that adequate access to all vital points of the building site must be secured, implying the necessity of a road whose layout and foundations will ensure the safe circulation of heavy lorries all the year round, and of snow ploughs and bulldozers at periods of heavy snowfalls; avalanche zones with protection walls must, of course, be provided.

Only such a road can ensure the transport of machinery and materials at an appropriate rate of speed and it goes without saying that adequate handling equipment must be available at both ends of the road immediately upon its completion, so as to guarantee the quick and safe handling of materials and equipment. As to cement, the author strongly advocates the use of steel containers conveyed to site by lorries or, better still, by cableways; these containers (see WATER POWER, May 1952, p. 177) can ply non-stop between the cement works and the primary silos on site. Special attention must also be paid, within the construction plant itself, to the layout of transport facilities between the various loading and unloading points; the conveying of workers to the building sites also requires a good organisation.

Particular stress is laid on a principle which must be applied as soon as concreting work at the dam is begun; operations must then proceed smoothly, without any spectacular rush periods and in accordance with a strict timetable based on the rate of concrete placing.

In conclusion, this article gives due consideration to the human equation involved in the operation of the construction plant. Shuttering and concreting crews, mechanics, electricians, cableway drivers, etc., all have a team spirit of their own but this is not enough and it is the task of the chief engineer and his assistants to co-ordinate these different team spirits into an "esprit de chantier," that is to say a corporate feeling embracing the whole of the plant. Once created, this feeling must be carefully maintained. The importance of this point is obvious on a building site which has but scant contacts with the amenities of the outer world. (Jean Emmanuel Dubochet, chief engineer of "Energie Ouest-Suisse" and "Grande Dixence S.A.", *Bulletin Technique de la Suisse Romande*, Vol. 72, No. 11/12, 13.6.1953, pp. 237/8.)

The Chastang Plant, Dordogne, France

Chastang is the last step of a 350 metre head development now almost fully completed, on a 100 km. stretch of the upper Dordogne. The Bort installation represents the first stage, the associated lake constituting the emergency reserve for the scheme; the storage level of the Marèges reservoir, the oldest of the valley and dating from 1935, is 125 metres lower. The third step, L'Aigle, commissioned shortly after the war, is 75 metres below the Marèges level, and its turbines discharge directly into the Chastang reservoir, which is 80 metres lower still. Downstream of Chastang, the Dordogne has a much easier slope and does not lend itself to large-scale development.

The Chastang dam, an arch gravity structure designed by M. Coyne, the well known French specialist, is 85 metres in height with a crest of 350 metres in length, and involves the placing of 250,000 cu. metres of concrete. The reservoir has a storage capacity of 180 million cu. metres, with a useful reserve of 38 million cu. metres. The two 13 metres wide ski-jump spillways can cope with a flood discharge of 4,000 cu. metres per sec., while two culverts provided in one of the two temporary diversions can pass 400 cu. metres per sec.; in addition, the other temporary diversion could pass a further 1,000 cu. metres per sec. through blasting the plug which normally obstructs it.

The main characteristics of the power plant are as follows:—

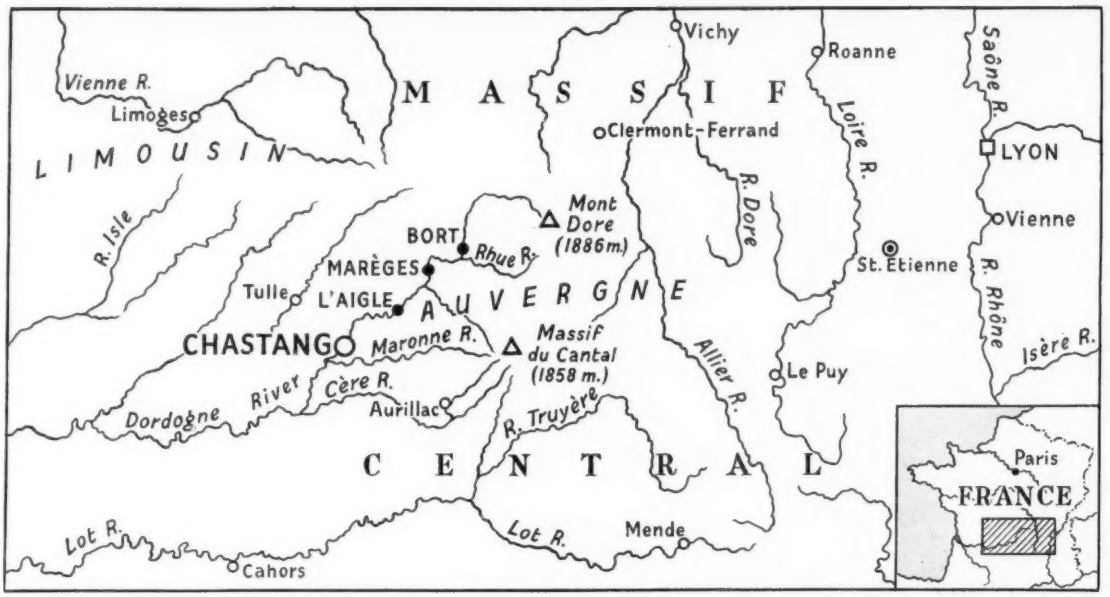
Gross head	72 metres
Installed capacity	250,000 kVA
Equipped discharge	405 cu. metres per sec.
Yearly production	540 million kWh

The three generating sets—two to be erected at the first construction stage and the third at a later date—consist each of a 115,000 h.p. vertical-axis Francis turbine, capable of developing a maximum of 134,000 h.p. under a 71 metre head, and of a 85,000 kVA/15 kV alternator; the rated speed is 150 r.p.m.

Each generating set is coupled to a 15/220 kV transformer capable of stepping up the tension to 400 kV. The transformer station is thoroughly protected from spray when the spillways are in operation. A 220 kV overhead line runs from this transformer station to the HV switching station at Le Breuil.

The power - station building presents unusual features; in the first place its size makes it one of the largest power houses in Europe—30 metres in height by 90 metres in overall length, with a span of 22 metres in width to accommodate the travelling cranes. In the second place, owing to the fact that each of its end-walls support a spillway, the total load is no less than 4,500 metric tons.

Chastang is intended as a peak-period plant which



Map of the Dordogne development showing location of Chastang

will not work more than 2,500 hours a year; it constitutes a typical "usine d'éclusée, utilising the releases from the upstream installations which, in addition to the three plants mentioned at the outset, include a number of plants on tributary streams. Taking into account the 400 million cu. metres of water available at Bort, it is expected that Chastang will seldom have to depend on the storage capacity of its own reservoir. (*La Houille Blanche*, Vol. 8, No. 3, June-July 1953, Pictorial Supplement, p. 423, 12 pp., 25 ff.)

High-head Hydro-electric Plants

This article deals exclusively with the Pelton turbines in operation in five power stations working under net heads which vary between 1,304·5 m. at Portillon, France, and 1,765·3 m. at Reisseck, Austria. The three other plants reviewed are Fully (1,600 m.), Dixence (1,740 m.), and Salanfe (1,441·3 m.). After a brief description of the plants, of which the oldest, Fully, was built in 1914, and the latest, Reisseck, commissioned in 1953, the improvements achieved in Pelton turbines in the course of these 40 years are listed as follows:—

(a) Power per wheel has increased from 3,000 to almost 50,000 h.p. (Salanfe-Miéville);

(b) Specific speed has risen successively from 2·7 to 7·04 initially, and subsequently to 12·25 and even 14·7 (metric units);

(c) The onerous solution of a wheel with detachable buckets of die-cast steel has given way to the bucket-ring of stainless steel, with disc and butt-strap, or to the stainless-steel wheel with integrally cast buckets, dimensions permitting;

(d) The elbow-type nozzle has been replaced by a straight annular nozzle, bifurcated in some instances, so as to improve the quality of the jet and the resistance of the buckets to wear and tear;

(e) The introduction of frequency-power governing in large power stations which assume the role of "conductor" in an interconnected system. (Pierre-H. Neeser, acting managing director "Ateliers des Charmilles," *Bulletin Technique de la Suisse Romande*, Vol. 79, No. 11/12, 13.6.1953, p. 242, 10 pp., 17 ff.)

Swiss 380-kV Transmission Lines

The following papers, read at the Conference of the Swiss Association of Electrical Engineers on December 5, 1952, in Zurich, are reproduced in the *Bulletin de l'Association Suisse des Electriciens*, together with an account of the discussion which concluded the conference:—

(a) *Economic problems and prospects of 380 kV transmission in Switzerland*, by G. Hunziker, Baden, p. 125, 4 pp., 1 f.

After a general survey of the lines existing in various countries for the transmission of electric energy at extra high voltages, the author deals with the economic and technical aspects of this type of transmission, taking as a basis, for the comparison of numerical data, a 200 km. transmission range. A comparison of transmission costs for 500 and 1,000 MW shows the economic advantages of the 380 kV system. Interconnection between neighbouring countries, topographical conditions, as well as the means of ensuring service continuity in the case of the failure of a single three-conductor section, are factors which will affect the erection of new 380 kV lines. The time at which determined sections are to shift over from HV to extra HV must be carefully chosen in each individual instance, all advantages and disadvantages being duly considered.

(b) *Insulation and overvoltages, stability of extra-HV transmission*, by K. Berger, Zurich, p. 129, 9 pp., 8 ff.

A brief survey is given of overvoltages likely to occur in extra-HV systems, and the dimensioning of insulators are discussed. The question is also examined as to whether the unipolar transmission of a short circuit can improve transmission stability, and in which cases it can be substituted for the quenching

coil of an unearthed system. This paper concludes with a general survey of operating reliability in extra-HV lines, and the advisability of providing for power reserves to meet disturbances.

(c) *Voltage Stability and Short-Circuit Protection in 380 kV Installations*, by W. Hauser, Olten, p. 137, 4 pp., 6 ff.

The author shows that 380 kV installations will present no circuit-breaking voltages of an abnormally high value, owing to the strong damping effect of the lines. Due account must, however, be taken of unipolar short-circuit currents which may endanger life and cause extensive damage; it is also advisable to investigate the influence of such currents on weak-current installations. Unipolar reclosing is a means of eliminating unipolar short-circuits. In 380 kV interconnected systems, it is highly desirable to avoid voltage differences, and voltage stability will, in this respect, play an important part. The author advocates the adoption of compensating means which will enable voltage to be stabilised in all sections of a system.

(d) *The 380 kV Overhead Line*, by R. Vögeli, Baden, p. 141, 4 pp., 9 ff.

Proceeding from the corona effect, which exerts an essential influence in the choice of the conductors for 380 kV lines, the author reviews the patterns of conductors in operation in various European countries. Taking a Swedish long-distance line as an example, he shows the relation between ohmic and corona losses. After a comparison of several types of insulator chains, the various arrangement of conductors on the pylons and the protection afforded by earth wires are discussed. This paper concludes with a consideration of overloads in relation to the type of conductors and the design of the pylons.

(e) *Transformers for 380 kV Transmission Lines*, by M. Itschner, Baden, p. 145, 7 pp., 13 ff.

The author shows that the high cost of insulation with 380 kV lines is justified only in conjunction with large-capacity transformer units. As such transformers must be transported in the completed state to their erection sites, it is necessary to build them with special types of winding, insulation, and ferro-magnetic cores.

(f) *Testing a 380 kV oil-jet Circuit Breaker on the line*, by E. Scherb, Aarau, p. 151, 3 pp., 3 ff., 3 tables.

This circuit-breaker, designed and manufactured by the Sprecher and Schuh concern in co-operation with the French Ateliers de Constructions Electriques de Delle, is similar to the 220 kV "Orthojecteur" briefly described in our issue of May 1953, p. 196, but built especially for the Swedish 380 kV grid. In addition to a brief description of the apparatus, this paper reviews, together with the results, the tests carried out in November 1952 at the Harspranget power station.

(g) *The Oerlikon 380 kV Circuit-Breaker*, by E. Vogelsanger, Zurich, p. 154, 3 pp., 6 ff.

The author describes the construction and working of this Minimum Oil Content Circuit Breaker which comprises two circuit-breaking elements coupled in series, and enclosed each in an insulating support. The circuit-breaking elements operate on the same principle as the well-known 60 to 220 kV circuit breakers of the Oerlikon concern. The reason which led to the adoption of double circuit-breaking are discussed, as well as the problem of the distribution of the voltage between the two gaps.

(h) *The Brown-Boveri 380 kV Circuit-Breaker*, by H. Meyer, Baden, p. 157, 5 pp., 8 ff.

This paper describes briefly a few characteristic features of this air-blast high-speed circuit breaker, extending to 380 kV a range of apparatus which began at 80 kV. Tests carried out in actual practice have proved that this circuit breaker fulfils all the operative requirements of distributing systems. A unit of this type, operating in conjunction with the Swedish grid at Harspranget has given full satisfaction.

(i) *Instrument Transformers and Compensating Equipment in 380 kV systems*, by A. Métraux, p. 162, 4 pp., 8 ff.

The construction of magnetic instrument-transformers is based on the principles which, for many years, have governed that of the 220 kV type. For reasons of economy it appears advantageous to use in their place other measuring apparatus, such as the capacitive potential transformer. Compensation of reactive power is effected by parallel capacitors in HV systems, as well as by series capacitors in 380 kV systems. This paper concludes with a summary of the rules which determine the construction and protection of these series capacitors.

The Wildegg-Brug Power Station, Switzerland

An account is given of the inauguration of this NOK concern on October 7, 1953. (*Bulletin of the Association Suisse des Electriciens*, Vol. 44, No. 22, 31.10.53, p. 971.)

Cavitation Laboratory for Hydraulic Turbines

An account is given of a new laboratory constructed by Dominion Engineering Works Limited at Lachine, Quebec, for the cavitation testing of reaction-type turbines. Many interesting features have been introduced to ensure exactness of control and accuracy of results, and to these ends the equipment is arranged in a closed circuit and standard 16 in. model runners are used. Thus it is possible to keep the head on the turbine constant and to vary the cavitation factor by varying the pressure level in the system, this being accomplished by changing the pressure equally in all parts of the circuit. The description is fully illustrated, and gives details of the instrumentation, the control system, and the calibration technique. (Hans Ulmann and R. S. Sproule, *Dominion Engineer*, Vol. XX, No. 4, 1953, 14 pp., 12ff.)

CLASSIFIED ADVERTISEMENTS

Announcements for this column can be accepted up to the 8th of the month for the following month's issue. The charges are fourpence per word with a minimum of 10s. Box No. facilities 2s. 6d. extra. In order to avoid accountancy it would be appreciated if instructions to insert were accompanied with remittance.

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